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ELEMENTARY SCIENCE TEACHING HINTS

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BAROMETERS

A study of some of the physical properties of air is found at nearly all grade levels. This may be found in units on air or in other units as weather, sound, etc. Some of the concepts included are:

1. Air pushes on things.
2. The pressure of air changes.
3. Air has weight.
4. The pressure of air is due to its weight.
5. Normal air pressure is 15 pounds per square inch.
6. Things move from regions of high pressure to regions of low pressure.
7. Air pressure is noticed only when it is unbalanced.
8. A barometer is used to measure air pressure.
9. Air pressure is an indicator of weather changes.

These concepts concerning air and air pressure vary greatly in complexity. Some can be mastered by primary grade pupils, some by intermediate grade pupils and some by upper elementary grade pupils.

Activities involving the making and use of simple barometers have been found helpful in developing a more complete understanding of some of these concepts. The construction of the barometers may be either a teacher or pupil activity. Pupils may also construct several different kinds of barometers and compare the results. Several different kinds of simple barometers are described here. These can all be constructed by pupils of the middle and upper grades and some can be constructed by pupils of the primary grades.

The barometer in Fig. 1 is made from: 1. a pop bottle, 2. a large mouth jar, and 3. water. To construct this follow these steps. 1. Fill jar A to a depth of two and one half to three inches with water. 2. Fill

bottle B approximately two thirds full of water. 3. Place a finger over the mouth of bottle B and invert it so that the mouth is immersed in the water in jar A. 4. Mark the level of the water in the pop bottle with a crayon, rubber band, or string.

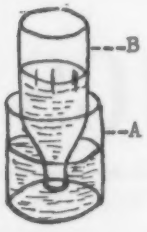

FIG. 1

FIG. 2

FIG. 3

When the air pressure increases the water level will rise in the pop bottle and when the air pressure decreases the water level will descend in the bottle. (In making this instrument be sure your materials are at room temperature as it is sensitive to temperature changes. You may also wish to add a small quantity of ink to the water to increase its visibility.)

The barometer in Fig. 2 is made from: 1. a milk bottle, 2. a soda straw, 3. a thin sheet of rubber, and 4. a piece of cardboard. To construct this follow these steps. 1. Tie a piece of light rubber over the

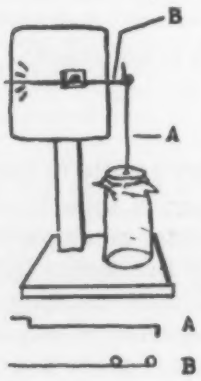

FIG. 4

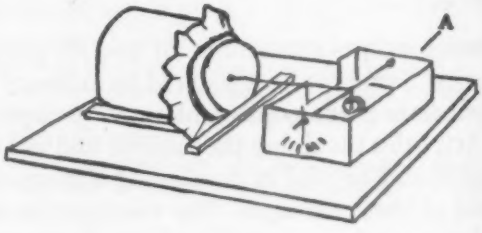

FIG. 5

mouth of the bottle. (A piece of rubber dam or toy balloon may be used.) 2. Fasten one end of the soda straw to the center of the rubber cover with glue or rubber cement. 3. Construct a scale from the cardboard.

When the air pressure increases the rubber cover will be pushed

down causing the straw to point up and when the air pressure decreases the rubber cover will be pushed up causing the straw to point down. (Use a clean dry bottle at room temperature as this instrument is sensitive to temperature changes.)

The instrument in Fig. 3 is a model of a Cape Cod type barometer and is made from: 1. a pop bottle, 2. a one hole stopper, 3. a piece of glass tubing, 4. a piece of wire, and 5. water. To construct this follow these steps. 1. Bend the glass tubing to the appropriate shape. 2. Insert the tubing into a one hole stopper of appropriate size. 3. Fill the pop bottle approximately one third full of water. 4. Insert the stopper into the pop bottle. 5. Invert the bottle and mark the level of the water in the tube with a crayon, rubber band, or string. 6. The hanger for the instrument is made from the wire. (An old wire coat hanger works well.)

When the air pressure increases the water level in the tube descends and when the air pressure decreases the water rises in the tube. (In making this instrument be sure your materials are at room temperature as it is sensitive to temperature changes. You may also wish to color the water with ink to increase its visibility.)

The instrument in Fig. 4 more closely resembles an aneroid barometer and is made from: 1. a large mouth vessel (tin can or glass jar), 2. a piece of thin rubber, 3. two pieces of light wire, 4. three pieces of wood, 5. a piece of cardboard, and 6. a number of tacks and small nails. To construct this follow these steps. 1. Tie a piece of rubber over the mouth of the vessel. 2. Cut one piece of wire about three inches long and form it as in A of Fig. 4. 3. Attach the looped end of the wire to the center of the rubber with glue or rubber cement. 4. Cut another piece of wire about three inches long and form it as in B of Fig. 4. 5. Construct a stand from the wood and cardboard and attach B to the stand with a large headed tack or small nail. Be sure the piece of wire can move freely around its support. 6. Insert the bent end of wire A into the loop at the end of wire B.

When the air pressure increases the rubber cover will be pushed down causing the pointer to move up and when the air pressure decreases the rubber cover will be pushed up causing the pointer to move down. (Use a clean dry vessel at room temperature as this instrument is sensitive to temperature changes.)

The barometer in Fig. 5 is similar to that sketched in Fig. 4. It is made from: 1. a large mouth vessel, 2. a piece of thin rubber, 3. a piece of thread, 4. a needle, 5. a broom straw, 6. several pieces of wood and cardboard, and 7. some small weights (nuts or washers). To construct this follow these steps. 1. Tie the piece of thin rubber over the mouth of the vessel. 2. Attach one end of the thread to the center of the rubber with glue or rubber cement. 3. The pointer ap-

paratus is made from a small cardboard box or formed from pieces of cardboard. The needle is passed through holes punched in the cardboard. (See A in Fig. 5). 4. The broom straw is passed through the eye of the needle and attached with glue or cement. 5. Assemble the apparatus as illustrated in the figure. Wrap the thread once around the needle. To the free end of the thread tie a small weight (a small nut or washer) but do not allow the weight to touch the board.

The movement of the rubber back and forth with the changes in air pressure will cause the thread to wind and unwind around the needle causing it to move in one direction for increased and the other for decreased pressure. (Use a vessel at room temperature as this instrument is sensititve to temperature changes.)

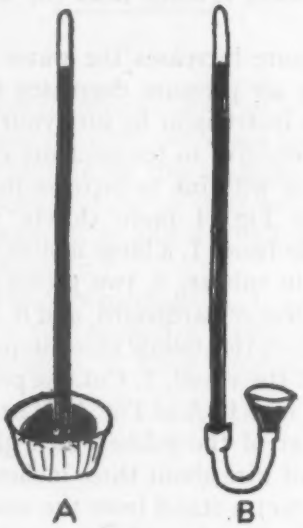

FIG. 6

The two instruments represented in Fig. 6 are mercurial barometers. Both of these instruments are made from sealed glass tubes filled with mercury. To construct barometer A follow these steps. 1. Pour a quantity of mercury into the vessel at the bottom. 2. Fill the tube with mercury. 3. Place a finger over the open end of the tube, invert the tube, and when the open end is immersed in the mercury in the vessel remove the finger. 4. Support the tube. To construct barometer B follow these steps. 1. Attach a funnel to the open end of the glass tube by means of a length of rubber tubing of the appropriate size. 2. Pour mercury into the funnel until the tube is filled and the mercury is coming up into the funnel. 3. Invert the tube. 4. Support the tube and funnel.

The length of the mercury column is the distance from the surface of the mercury in the vessel or funnel to the top of the mercury in the tube. When the air pressure increases the column of mercury goes up and when the air pressure decreases the column goes down.

To further demonstrate the action of a barometer the following is suggested. Secure a large pickle or mustard jar. Place in it a barometer of the type indicated in Fig. 1, 2, 3, or 4. (See Fig. 7.) Punch a hole in the metal cover of the jar so that a one hole stopper can be inserted.

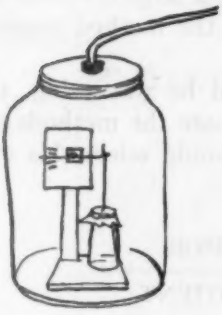

FIG. 7

FIG. 8

Screw the top of the jar into place. Attach a length of rubber tubing to the stopper by means of a short piece of glass tubing. Pupils may blow into this tube and note the results.

If rubber tubing is not available cover the mouth of the jar with a sheet of thin rubber. (See Fig. 8.) To change the pressure in the jar pupils need only push down or lift up on the rubber covering. The results are easily observed.

NEWSREELS FOR SCHOOLS

In response to an increasing number of requests for newsreels from school systems all over the country, Telenews is making its *Weekly News Review* available for school use at a nominal rental charge.

Telenews, the largest producer of television news films, prepares the *Weekly News Review* specifically for use on TV. However, a series of use-tests during the 1951–52 school year by social studies instructors has shown the weekly issues to be valuable in current events and civics studies. Each week's release is made up of news stories filmed in all parts of the world by Telenews camera staffs. Delivered on 16-mm. film, each issue is in essence a carefully-edited 15-minute summary of the international news highlights of the week.

Details may be obtained from Richard Milbauer, Telenews Productions, Inc., 630 Ninth Avenue, New York 36, N.Y.

A SHORT METHOD OF LONG DIVISION

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While teaching mathematics at Cass Technical High Evening School in Detroit, the author had a young French student in one of his classes, and it was not long before he noticed that the student computed long division in a way similar to the American method but not exactly the same. It appeared to be a short cut method, and although it did not save time on short problems, the French student was always through with his division of a large dividend long before any of the other students finished by the method commonly used here in the United States.

When questioned about the method he was using, the French student stated that if he were to compare the methods of teaching in the United States and France, he would select this one thing—

Here are some examples:

DIVIDEND | DIVISOR

QUOTIENT

EXAMPLE I

AMERICAN

```
      22
  2 ) 44
      4
      04
      4
      0
```

FRENCH

```
44 | 2
04 | 22
 0
```

When you multiply the divisor by the quotient, you do not write the product but only the remainder.

EXAMPLE II

AMERICAN

```
       247.13
  23 ) 5684.00
       46
       108
       92
       164
       161
        30
        23
         70
         69
          1 remainder
```

FRENCH

```
5684.00 | 23
108     | 247.13
 164
  30
   70
    1 remainder
```

that is, long division—as the most different or frustrating. He said there was too much lost motion with the American method.

Since, according to him, his method was the one commonly taught in France, and also since the author had observed its superiority as far as speed was concerned, he decided to learn how it was done.

Everyone is familiar with the saying that "it is hard to teach an old dog new tricks," and most of us probably feel we would rather continue with the method with which we are already familiar. However, the similarity between the French and the American methods is so great that the carry over makes learning the French method relatively simple.

EXAMPLE III

AMERICAN

```
      3990.88
17 | 67845.00
     51
     ---
     168
     153
     ---
      154
      153
      ---
       150
       136
       ---
        140
        136
        ---
          4 remainder
```

FRENCH

```
67845 | 17
168   | 3990.88
 154
  15⁴0
    140
      4 remainder
```

Notice that there is no decimal in the divisor, so as soon as the last digit (5) is brought down and the divisor goes into it, the decimal point, in the French method, is placed in the quotient.

Also notice that when $8 \times 17 = 136$, you can subtract by saying

EXAMPLE IV

AMERICAN

```
      5546.53
13 | 72105.00
     65
     ---
     71
     65
     ---
      60
      52
      ---
       85
       78
       ---
        70
        65
        ---
         50
         39
         --
         11 remainder
```

FRENCH

```
7²2105 | 13
 7²1   | 5546.53
  6³0
   8⁵5
    7³0
     5¹0
       11 remainder
```

"from 60 take 56," then carry the 6 and add to 8 to make 14 which you subtract from 15 to get a remainder of 1.

A word of caution: Since it is the 6 you are to carry and must remember, always say "from 60 take 56," not "56 from 60."

13 goes into 72 five times. When you multiply, $5\times3=15$; then from 22 take 15 to get a remainder of 7. Carry the 2 and add to 5 (the multiplier) to get 7. Subtracting 7 from 7, the remainder is zero.

EXAMPLE V

AMERICAN

```
      30.7109
  8 | 245.6872
    24
    ---
     56
     56
     --
      8
      8
      -
     72
     72
     --
```

FRENCH

```
245.6872 | 8
05 6     | ------
  08     | 30.7109
  072
   72
```

EXAMPLE VI

AMERICAN

```
          1010.81
3.42∧ | 3456.97∧20
      342
      ---
       369
       342
       ---
        2772
        2736
        ----
         360
         342
         ---
          18 remainder
```

FRENCH

```
3456.97∧20 | 3.42∧
36 9       | ------
2 7²7²2    | 1010.81
   360
    18 remainder
```

The decimal is shifted in the dividend the same number of places as in the divisor.

In the problem above, when multiplying by 8 in the middle of the quotient, $8\times2=16$ and then subtract from 22; carry the 2 and multiply $8\times4=32+2=34$ and subtract from 37 to get 3 as a remainder. $8\times3=24+3$ to carry is 27. Subtract 27 from 27 to get the remainder of zero.

"Snorkel" fountain pen with tube that can be plunged into ink is filled without wetting the pen point. After filling, the Snorkel tube is drawn back under the pen's nib. Because of its new design, "leaks" are avoided in the pen that often are due to decreased air pressures during airplane trips or to increased temperatures inside the pen while it is being used.

SCIENCE ARTICLES FOR THE LAYMAN

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More and more, as the evidence in this study would seem to suggest, science subject matter is finding its way into articles intended for lay reading. This applies to articles found in general culture or general information periodicals. The science subject matter is not limited to practical applications or inventions but includes pure science and is sometimes sufficiently advanced as to require a decided technical background for comprehension. Some recent astronomical articles in *Harper's Magazine* caught the attention of the author and inspired her to carry on the following investigation.

SELECTION OF LAY LITERATURE

It was decided to limit the study to a small number of periodicals which would meet the following criteria. They must have a wide circulation, be aimed at the intelligent public, and be serious in nature. In addition, it was important that the magazines not give so much space to science or technology as to particularly attract readers of definite scientific interests. The *Scientific American*, for example, was omitted for this reason. Although articles in the latter magazine are designed for lay consumption, it has turned out that a large part of the readers are engineers or scientists who wish to keep up with scientific accomplishments outside their own special fields. These readers cannot be considered as true laymen even in a branch of science other than their own. Furthermore when 100% of the articles in a magazine deal with scientific subjects, it is not possible to study a trend as to the prevalence of such articles.

Two monthly magazines: *Harper's* and *The Atlantic;* and two weeklies: *Time* and *Newsweek* were selected for the study. Each article or announcement concerning science in every issue during the year 1950 was examined. Because of the small number of articles per year in *Harper's* and *The Atlantic*, the issues for 1951 were also examined. The issues of *Harper's* for 1940 and 1930 were similarly studied for evidence of any change in policy as to the emphasis on science articles.

ANALYSIS OF DATA

Each article was examined for its topic (as expressed in the title) and the nature of the information given. The articles were classified as to the branch of science involved. This was admittedly subjective and, indeed, often very difficult. In fact, it was not always clear as to whether an article dealt with science or not. Some articles seemed

to be concerned primarily with military strategy rather than science, but were included here because the topic was in science. Articles on the atomic bomb were sometimes interested in the nature of radioactivity and sometimes dealt more specifically with civil defense. Both types of articles were included because, here again, the topic seemed definitely to belong to the field of science.

In the original classification of each article, certain arbitrary distinctions were made within a branch of science. Material on Diesel engines, for example, was originally classed under *engines* and later, in some cases as specified below, *engines* were included with *physics*. Articles dealing specifically with *nutrition* were at first classified separately from *biochemistry*. Almost nothing was classified as *biology*, but groups called: *plants*, *animals*, *population*, *genetics*, etc. were used. In choosing the titles for this subject matter classification, the author had in mind the particular emphasis of the article. The titles were not determined in advance but were selected one by one as each article was studied.

Each article in *Harper's* and *The Atlantic* was studied to determine what, if any, background in science would be needed by the reader in order to understand the article in a satisfying manner. This presented some difficulty but the conclusions stated herein seem definite to the author.

Results

The total number of articles or news items dealing with science are tabulated in Table 1. Of course it is to be expected that *Time* and

Table 1. Prevalence of Science Articles in Lay Periodicals

Year	Periodical	Number of Science Articles or News Items
1930	*Harper's*	3
1940	*Harper's*	14
1950	*Harper's*	17
1951	*Harper's*	21
1950	*Atlantic*	6
1951	*Atlantic*	9
1950	*Time*	114
1950	*Newsweek*	147

Newsweek would have large totals since many of these are short announcements. The reader will also note that *Harper's* seems much more favorably disposed toward science articles than the *Atlantic*. It is also true that none of the *Atlantic* articles required science backgrounds on the part of the reader. Seven of *Harper's* articles

definitely required such a background and in six others some background is desirable.

A decided increase in emphasis on science articles is evident in *Harper's* between 1930 and 1951. The great awakening (from a science teacher's viewpoint) seems to have occurred in the 1930's. It is also worthy of note that in none of the articles in 1930 was any science background needed. In 1940 there were two articles for which a background on the part of the reader would be helpful. The other four articles where the science background is helpful and those where it is necessary are in the 1950 and 1951 issues. This probably indicates an increase in both number and technicality of the *Harper's* science articles. The author sees no significance in the difference in numbers of items between *Time* and *Newsweek*. Perhaps there is a slight difference in collection criteria or in collection techniques.

The distribution in different subject matter classifications is interesting for *Time* and *Newsweek* because of the large totals involved. These results from the two periodicals have been added together in Table 2. In general each periodical contributes its proportional share to the total in each classification. It will be noted that physics wins out by far in proportion of articles. Chemistry holds a much less prominent place but this is partly because topics dealing with

TABLE 2. CLASSIFICATION OF SCIENCE ITEMS FROM *Time* AND *Newsweek* FOR 1950

Topic	Number of Articles	Percentage of Articles
Physics	73	28.0
Animals	32	12.3
Aviation, engines, automobiles	26	10.0
Astronomy	17	6.5
Agriculture and plants	13	5.0
Biochemistry and nutrition	12	4.6
Physiology	11	4.1
Chemistry	10	3.8
Geology and petroleum	8	3.1
Psychology	7	2.7
Anthropology and archeology	7	2.7
Meteorology	6	2.3
General (research policies, education of scientists, etc.)	6	2.3
Biology, genetics, paleontology	4	1.5
Calculating machines	3	1.1
Military	3	1.1
Geography	2	0.8
Gerontology	1	0.4
Miscellaneous	20	7.6
Total	261	99.9

radioactivity and atomic theory were classified as physics, although they could have been classed as chemistry, and partly because biochemistry topics were treated in a separate group. Animals seems to be an ever popular subject as well as aviation, engines, and automobiles. Astronomy holds a rather surprizingly high position in popularity.

Table 3 presents the subject matter classifications for *Harper's Magazine*. The numbers are small but one can see a slight predominance of physics and biochemistry. The seven astronomy articles appearing in 1950 and 1951 may be of less significance than would

TABLE 3. CLASSIFICATION OF SCIENCE ARTICLES FROM *Harper's Magazine*

Topic	Number of Articles			
	1930	1940	1950	1951
Physics (including meteorology and engines)	0	3	5	2
Astronomy	0	0	2	5
Chemistry	0	1	0	1
Biochemistry	0	4	4	2
Bacteriology	0	1	0	2
Geology	0	0	1	3
Paleontology	0	0	1	1
Psychology	0	1	1	1

Topics which occurred less than twice in the four years are omitted.

be apparent from the table since five of them represent a series by Fred Hoyle and should perhaps be treated as one. The series does, however, represent a large amount of space devoted to the subject. It is remarkable that the seven astronomy articles are those which definitely require a science background (a major in astronomy, I should think; or a year of astronomy with considerable physics) if the reader is to utilize any judgment in evaluating and even in comprehending the points that are made. These astronomy articles are the only ones requiring such a technical background. In other articles such a background is either not needed or merely helpful.

In Table 3 those topics which appear once only in the entire four years under study were omitted. Since the 1930 articles do not show at all, the reader may note here that one of these science articles dealt with philosophical aspects, one with health, and one with animals.

In 1950 the *Atlantic* published two physics articles. Other topics did not occur more than once. Five physics articles appeared in the *Atlantic* in 1951 although these did not involve much physics but

were from civil defense, military strategy, or other general viewpoints.

THE *Harper's* ARTICLES

Some further discussion of the *Harper's* 1950 and 1951 articles may be desirable since these seem to represent a trend toward the increase in science material presented for lay reading. The astronomy articles have already been mentioned as requiring a technical knowledge of astronomy on the part of the reader. The author does not see how the material in these articles could be presented without the technical material. The series of five articles by Fred Hoyle describes the nature of stars and the universe so as to lead up to the theory of the continuous creation of matter. This is one of the two current theories on the origin of matter in the universe. The other which does not involve the continuous production of matter, actually dates the creation of the universe at 3 or 4 billion years ago. This has not been included in *Harper's* during the two years considered. It would be equally difficult reading, however. These two theories are controversial but represent a significant activity in astronomy today, and one which is appropriate for the layman who can understand it. The other astronomy articles had to do with Velikovsky's book of a few years ago, *Worlds in Collision*. This has been a well advertized book which may mislead the unsuspecting layman. It is a book that cannot be very well evaluated by the non-scientist. In fact several people in high places found themselves considerably embarrassed as a result of their favorable reaction to it. In one of the articles Velikovsky and two of his critics answer each other.

An article in 1950 gave a short biography of Vincent Schaefer and described his experiments at General Electric in connection with rainmaking. This was a good and timely article. Some science background would be helpful. Terms such as *precipitation nuclei, sublimation nuclei, cumulus clouds* were used as well as chemical names such as *silver iodide*. The article presented an account of the extent of success in rainmaking and the reason for Schaefer's caution about the possibilities.

Atomic energy accounted for many of the physics articles. There was one in 1950 on atomic engines. This included material on atomic fission and a discussion of types of reactors. Some science background is desirable for the reader of this article. It was surprizing, indeed, to find an article on atomic power in the June 1940 issue. John J. O'Neill wrote under the title, *Enter Atomic Power* at that time. He describes experiments with the uranium isotope of mass 235 and

suggests applications. The article must have just preceded the policy of secrecy which prevailed during the development of the atomic bomb. Some technical knowledge of radioactivity is also needed here by the reader.

The biochemistry articles dealt mainly with cortisone and its relatives. An article in 1951 mentions some organic syntheses and makes a knowledge of organic chemistry helpful but not obligatory.

There was an article in 1950 called, *The Snout* which considered certain aspects of evolution and the effect of environment. A few paleontological and zoological terms were included but not enough to say that any scientific background is needed by the reader.

Other articles during the two years included one on smog, on virus diseases, on the Labrador iron mine construction, on the available plant food resources in Central America and their nutritive values, etc. Two articles dealt with the increasing automaticity in the manufacturing process. One was concerned with electronic machines and the other with a large organic chemical plant which is highly automatic. The use of dowsing as a technique for locating underground water supplies was argued pro and con in two articles evidently inspired by a book of Kenneth Robert's. The author of an article in 1951 entitled, *Can Science Make Sense?* was alarmed by the difficulty experienced by science specialists in understanding other branches of science.

The author of the present study found the *Harper's* selection of science articles very appropriate and feels that the editors should be congratulated.

Conclusions

From this study it is evident that science is by no means being neglected in current periodicals intended for lay readers. In *Harper's* an important magazine for laymen, the number of science articles has been increasing since 1930. The amount of technical information in *Harper's* articles is greater in recent years than in the past. In some recent articles a science background on the part of the reader is assumed. The *Atlantic Monthly* has fewer science articles than *Harper's* and less technical ones, but the subject has not been completely neglected. The science articles and announcements in the weekly periodicals, *Time* and *Newsweek* are numerous, being more than 100 in each for 1950. Articles dealing with phases of physics seem to predominate over any other subject. Topics which received considerable emphasis include:

Atomic energy and radioactivity
Astronomy and the universe

Aviation and engines
Biochemistry, nutrition, bacteriology
Animals: descriptions and experiments
Rainmaking

In the *Atlantic* some emphasis was found on military needs and uses and civilian defense against the atomic bomb. Articles in this periodical were handled in such a way as never to require a science background for the reader. This was true in spite of the fact that the authors included such prominent scientists and engineers as I. I. Rabi and Norbert Wiener.

TEACHERS FROM OTHER LANDS

Two hundred and seventy-one teachers, supervisors, and school administrators from 47 different countries throughout the world have arrived in the United States to spend six months studying and observing American educational theory and practice.

The Office of Education of the Federal Security Agency cooperates with the Department of State in administering this teacher training program as authorized by the Smith-Mundt and Fulbright Acts.

Earl James McGrath, U. S. Commissioner of Education, said today (Sept. 12), "Within a week there will be a total of 312 of these leaders in education with us from 49 different countries. Specializing in elementary, secondary and vocational education, and teaching English as a second language, these educators have been selected to obtain practical experience this academic year in selected school systems and in a number of our leading institutions of higher education. They come from countries in the Far and Near East, the American Republics area, and Europe."

During the remainder of the week the visitors have been attending orientation lectures in the Federal Security Auditorium, after which they will leave to attend special institutes and seminars. Universities the visiting educators will attend include Indiana University, Colorado State College of Education at Greeley, Iowa State Teachers College, Pennsylvania State College, Ohio State University, Teachers College, Columbia University, University of Michigan, University of Connecticut, Syracuse University, and Stanford University.

Addressing the educators from other countries in the Federal Security Auditorium, U. S. Commissioner of Education McGrath explained the leadership function in American education exercised by the U. S. Office of Education as contrasted with the actual control of education by the national ministries in other countries. "Whatever leadership we give is through force of logic and persuasion," Commissioner McGrath said.

"As you go into communities throughout the Nation," he told the teachers and school administrators from many other countries, "you will be free to talk to any person, to ask any questions that occur to you, and you will receive honest answers from the citizens of the United States. No curtain will be hung before you in any community. No officer in Government will be observing you. You can see us as we are."

Saying that many Americans regard educational programs of this type as the best guarantee to a lasting peace in the world, Commissioner McGrath added, "In the last analysis we can get peace only by mutual understanding and mutual aid. This requires faith, but educators are accustomed to faith."

THE LAWS OF FALLING BODIES

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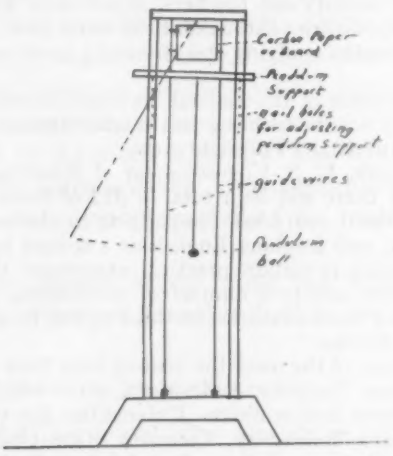
The laws of falling bodies are often neglected in the high school laboratory because of the difficulty in measuring the short time required for the body to fall the few feet necessary for the laboratory; this can be overcome by combining the fall of the body with the swing of a pendulum to measure the time of fall.

In practice two sticks each about six feet long and an inch and half square are placed on a tripod base about a foot apart and connected at the top with a cross piece. A piece of one half inch soft wood board about six inches square is made to fall between two guide wires that run through screw eyes on opposite edges of the board. The board is



covered with a piece of white paper covered with a like sized piece of carbon paper fastened to the board with thumb tacks. The guide wires are fastened to the top cross piece and to a similar piece at the bottom just far enough apart so the board will fall freely between them. A string attached to the top of the board is run through a screw-eye attached to the cross piece at the top and midway between the guide wires, then back down. A metal ball on a string is attached to a moveable cross piece on the uprights in such away that it swings in the path of the falling board and just touches it when at rest. If a second string is attached to this pendulum ball and the ball is drawn aside while the string attached to the board is pulled to draw the board to the top of the frame, the experiment is ready for trial. It is well to hold both strings with one hand so both can be released at the same time. When the strings are released the ball swings to meet the

falling board. If the pendulum is the right length, the ball hits the board as it falls and leaves a carbon mark on the white paper.

Of course the pendulum must be the right length in order for the ball to hit the board as it passes. This relation can be determined by trial or it can be determined from the known laws of the pendulum and of falling bodies.

Let $s = gt^2/2$ be the distance of fall and
$T = 2\pi\sqrt{L/g}$ be the period of the pendulum.

Then $s = gt^2/2 = \frac{g\pi^2 L}{8\,g} = \frac{\pi^2 L}{8} = 1.23\ L$ approximately.

The distance of fall can be measured by raising the board to the top of the frame and measuring from the mark on the board to the pendulum ball suspended below it. The period of the pendulum may be determined by counting the swings in two or three minutes as determined by a common watch or an electric clock. Of course the time

Fall, ft.	Swings/ min.	Period, sec.	Period/4, sec.	Av. Velocity, ft./sec.	Final Velocity, ft./sec.	g ft./sec.^{2}
4.85	27	2.22	.555	8.86	17.72	31.9
4.90						
5.02						
4.92						
4.15	30	2	.5	8	16	32
3.96						
3.90						
4.003						
3.17	35	1.715	.428	6.86	13.72	32.1
2.81						
2.85						
2.94						
2.17	42	1.43	.358	5.73	11.46	32.0
2.15						
1.83						
2.05						
1.08	60	1	.25	4.08	8.16	32.6
1.02						
.96						
1.02						
						32.2

of fall is just one quarter of a period. These measurements can be made with sufficient accuracy to satisfy most students.

After several trials at different distances of fall and corresponding pendulum lengths, the average velocity of each fall and corresponding time can be determined. An examination of these data will show clearly that the average velocity in each case is directly proportional to the time of fall. The final velocity each time must be, then, twice the average velocity. If now the final velocity in each period of time is divided by that time the increase in velocity per second is found and this is the acceleration due to gravity.

The following data were taken by two New Sharon high school juniors who had never studied physics. Alcide Gosselin and Donald Hoxie took all the data and did the computing under the guidance of Mr. William Kelly.

INDUSTRY IN "MAN HUNT" FOR MANAGERIAL TALENT, PRICE DECLARES

American industry is engaged in a determined "man hunt" for managerial talent—a hunt for tomorrow's managers who will face "graver problems and greater decisions" than ever before, Gwilym A. Price, president of Westinghouse Electric Corporation, told the Third Annual Fellowship Dinner meeting of Carnegie Institute of Technology alumni, Pittsburgh, Pa. Success in this "great American man hunt," depends on close cooperation between U. S. industry and universities.

"Every company is constantly seeking ways to assess human abilities, and so to eliminate the risks of accident and haphazard choice in the selection of its leaders," Mr. Price said. "All are striving to find future managers earlier, to keep track of them once they have been found, to challenge them to realize their full capacities, to train them more thoroughly and prepare them better for promotion."

"Our plans for the choice of management men must be just as careful, just as systematic, as those for the design of our new products, the schedule of our production, the extent of the facilities we will need," Mr. Price declared.

In this search for management talent the nation's universities and colleges have played an increasingly important role, with industry now realizing that education must not end with graduation, the Westinghouse president said. More than ever, business is asking for educational aid in advanced training for management.

Mr. Price cited Carnegie Tech's new Graduate School of Industrial Administration as one example of the help educational institutions now are providing. Other examples he mentioned were the University of Pittsburgh's courses in Management Problems for Executives, Harvard's 13-week course for executives, the Leland Stanford summer program for managers and the new MIT management school.

Household fire extinguisher weighs 2½ pounds and squirts a vaporizing liquid in a 25-foot stream by compressed air controlled by a push-button switch. The extinguisher's air pressure can be recharged at a filling station. Having a stainless-steel shell and a red plastic head, the extinguisher works against ordinary small fires in wood shavings, waste baskets, wiring and household appliances.

THE CONTRIBUTION OF ARITHMETIC TO THE STUDY OF GEOGRAPHY

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In the geography studies of the fifth and sixth grades, there is frequent need for thinking in terms of number. Sometimes the textbooks clarify statements involving number by means of comparisons. Occasionally charts, graphs or diagrams help to give meaning to the statements. Many times, however, when such ideas are expressed, the authors seem to take for granted that our ten and eleven year olds have the arithmetical background to make the facts meaningful, or they are confident that the teacher will grasp the opportunity to provide activities which will make the thinking as concrete as possible. Whether the geography study is motivation for meaningful lessons in arithmetic, or arithmetic is used to clarify geographical thinking, is immaterial.

In tabulating statements in texts of fifth and sixth grade geography, it was found that number material falls into the following categories: area, population, distance, latitude, climate, elevation, production, trade, and subjects related to them. Excerpts from several of these textbooks are here presented, together with a sampling of arithmetic activities which have been used in my Lakewood classes. Space does not permit the extensive quoting of textual material, but references used have bearing on the topics under consideration and are typical.

All modern geography texts have excellent maps with keys to interpret the symbols used. Dots of different sizes, to represent cities, classify them into population groups. The actual population of capitals and large cities is usually given in charts. By the time pupils reach the sixth grade, they are familiar with the *World Almanac*, and use it in finding the latest population data. Pupils need help, however, in reading these statistics and in expressing them in round numbers.

The population of a region is an important consideration and questions which arise from the reading of a population map can motivate investigations along many lines. Sometimes the population of a region is shown on a dot map. Sometimes, it is represented by map shading. Fifth grade classes are interested in their own locality, state, and region. If they live in a city, they know that in it there are the homes of a large number of people. But they need help in visualizing specific numbers. A baseball game, with a stadium filled with 80,000 spectators, has possibilities in making population figures meaningful. The arithmetic program should provide references of this sort in various fields of measurement.

Comparing the population of the large cities of a state may serve as the introduction to bar graphs, and the growth of a city through past decades has proved an interesting way to present line graphs to a class. Reading and interpretation of graphs must receive careful consideration before the children attempt to make them. The first graph making efforts should be directed. Usually there are a few pupils in every class who find graphs so interesting that they look for other opportunities to express statistics in this manner.

As the word per cent is frequently used, it is necessary to explain this phase of arithmetic, or to change the figures to common fractions which fifth and sixth grade children understand. Children enjoy making graphs using stick men of different colors to show racial distribution in countries of Latin America. They have found bar graphs helpful in comparing the area of the United States with that of other countries, such as Canada, Brazil, or Argentina.

Area and Population

Since population densities are frequently referred to in texts, it is well for pupils to compute the density in their own state and county as well as that of the United States as a means of comparison. A very simple but striking way to show population densities of the states, is a dot map which the children make. Using an outline map, a dot is placed on each state for each 200,000 people within its borders. This calls for the use of the latest census information, and involves some figuring in determining the number of dots each state needs. Care must be taken to keep the dots uniform in size. This may be a cooperative activity with a large map, or individual projects with smaller desk maps. Using dots to represent numbers of people, can motivate an investigation into latitude, climate, topography, occupations, and other geographic relationships.

Samples of Number Material Dealing with Area and Population

Atwood and Thomas, *The American Nations*, page 248.

"Canada is a huge country. It is larger than continental United States and Alaska together, and yet it has only about one-twelfth as many people."

Barrows, Parker and Sorensen, *The American Continents*, page 212.

"Puerto Rico has too many people and too little land. About 500 people must make a living from each square mile of land."

Whipple and James, *Neighbors on Our Earth*, page 156.

"When Buenos Aires was opened as a port, only about 24,000 people lived there. A hundred years ago the population was only 90,000. Today it is counted at over 3,000,000, having gained about 2,000,000 in the last forty years."

Carpenter, *Our South American Neighbors*, page 232.

"Peru's population is composed of: 8 per cent whites; 45 per cent mestizos; 47 per cent Indians."

Distance and Size

Children need to be familiar with measures of distance, height, width, area, volume, and weight. They have occasion to use map scales to measure and estimate heights and distances. We attempt to set up some standard units of reference which are of service, such as: the size of our schoolyard as expressed in acres; the height of our school building; the approximate height of the cliff at our lake front; the distance from our school to downtown Cleveland; the distance from Lakewood to other cities with which members of the class are familiar.

Samples of Number Material Dealing with Distance and Size

Stull and Hatch, *Journeys through the Americas*, page 262.

"Newfoundland lies . . . less than 2000 miles from the west coast of Ireland, or about half the distance between New York and Ireland."

Barrows, Parker and Sorensen, *The American Continents*, page 180.

"In the east (Great Plains) many farms contain 160 acres or less. In the west few ranches contain less than 1000 acres. Some ranches contain many thousands of acres."

Stull and Hatch, *Journeys through the Americas*, page 220.

"Sequoias: Many of these trees are between 3000 and 4000 years. . . . Thousands of them are over ten feet thick. The General Sherman Tree is 280 feet high and over 30 feet thick.

Latitude

As soon as children graduate from the very simple forms of maps and globes, they become acquainted with the map grid, and learn to think of a degree of latitude as approximately 70 miles. The pupils not only estimate latitude from a map, but find the exact measurements of latitude in an atlas. They find the difference in latitude between places on the American continents.

Samples of Number Material Dealing with Latitude

Barrows, Parker and Sorensen, *The American Continents*, page 7.

"If a plane flew from a place on the equator due north to the North Pole it would fly 90 degrees. Each of these degrees is about 70 miles long. The numbers on the east-west lines on the map show how far from the equator places are."

Whipple and James, *Neighbors on Our Earth*, page 114.

"Chile stretches for a distance of 2630 miles along the west coast of South America from about latitude 18 south to latitude 56 south. Thus it is partly in the low latitudes and partly in the middle latitudes."

Climate

Before they reach the fifth grade, children learn about many places in our world. These places have different types of climate. In the fifth grade they find a variety of climatic conditions in our own land. The length of the growing season and the amount of rainfall help to

explain the different types of agriculture and certain areas of sparse population. As we leave our land and travel north and south even greater differences are apparent.

Climatic conditions at stations in various regions are recorded graphically. The slated graph puts such data before the entire class, and aids in graph reading and interpretation. Climatic charts are duplicated and given to the children for study of the annual temperature range and the rainfall of many stations. Climatic study is sometimes made more personal and interesting through letters from pen pals which often include items about the weather.

Samples of Number Material Dealing with Climate

Whipple and James, *Neighbors on Our Earth*, page 120.
"Wheat must have growing season of at least three months."

Barrows, Parker and Sorensen, *The American Continents*, page 192.
"In southern Washington the rainfall is about 11 or 12 inches a year. That is not enough even for wheat."

Barrows, Parker and Sorensen, *The American Continents*, page 215.
"The farm lands near Fairbanks are farther north than any others in Alaska. The temperature there may drop to zero or below on about two-thirds of the days in a year. . . . The growing season is very short, but summer days are very long and so crops grow rapidly. At the end of June the sun is above the horizon about 21 hours a day."

Elevation

We find many references to the height of mountain peaks and other references to elevations. Color bands on our physical maps also suggest different elevations. The children learn that where these color bands are narrow the rise is abrupt.

In their science studies, the children have learned that when the altitude increases, the temperature decreases. They find it interesting to know that the change is at the rate of about three degrees for a thousand feet. This becomes very significant when we study tropical and subtropical lands and learn that the most desirable places in which to live are the higher elevations, which are sparsely populated in middle latitudes.

Samples of Number Material Dealing with Elevation

Atwood and Thomas, *The American Nations*, page 273.
"Three climates: First, there is the tierra caliente, or hot land. This is the land between sea level and about 3000 feet. The greater part of Mexico however, is higher and therefore cooler. The parts which are from about 3000 feet to 8000 feet in elevation make up what the Mexicans call the tierra templada or temperate land. The tierra fria or cold land is made up of the parts of the mountains which rise so high that their weather is chilly or cold the year round."

Stull and Hatch, *Journeys through the Americas*, page 13.
"The Mile High City—Denver, Colorado, was given this name because it is exactly one mile above sea level."

Barrows, Parker and Sorensen, *The American Continents*, page 272.
"Probably the highest dwelling in the world is a shepherd's hut in Peru at about 17,000 feet above sea level."

Time

The element of time also enters largely into geographic studies. The hours of daylight, the length of the growing season, time consumed in travel by land, sea, and air, are all important factors.

Samples of Number Material Dealing with Time

Stull and Hatch. *Journeys through the Americas*, page 272.
"The summers are short but warm, with the sun shining from 18 to 24 hours a day."
Whipple and James, *Neighbors on Our Earth*, page 50.
"On the train less than an hour and a half is required to cross the Isthmus."

Production and Trade

Textual material about resources, land-use, production, and trade make frequent use of numbers. Dot maps are sometimes employed by the authors to show locational densities, and occasionally graphs and charts are used.

Samples of Number Material Dealing with Production and Trade

Stull and Hatch, *Journeys through the Americas*, page 295.
"The United Fruit Company has nearly 30,000,000 acres of banana farms in Guatemala alone. Each plantation is divided into farms of 1000 acres and these into twenty-one-acre sections which are let out to native farmers."
Atwood and Thomas, *The American Nations*, page 284.
"Usually about four-fifths of all the exports of bananas from Central American republics come to the United States."
Whipple and James, *Neighbors on Our Earth*, page 42.
"Although the banana plant is not a tree, it grows from 15 to 30 feet tall with a stem from eight to sixteen inches thick."

It will be apparent that many of the references have more than one number relationship. Time in the classroom will not permit the development of every number idea which is presented. The interests and needs of the class determine how far we can go.

The handling of different kinds of reference tools is a valuable experience. The boys and girls learn that the *World Almanac* is useful for current statistical data and each one is given plenty of practice in using it. The Statistical Abstract of the United States is occasionally consulted. *Goode's Atlas* is used constantly for absolute location. As the latitude numbers include hundredths, decimals are brought into our thinking. Material from the *Foreign Commerce Yearbook*, such as United States imports of bananas, coffee, and sugar, is brought to the attention of the class.

Information from sources other than books is also used. There are items in daily newspapers and in magazines. The United Fruit Com-

pany, Pan American Coffee Bureau, and several sugar importing companies have sent us interesting pamphlets. When the question came up concerning amounts of grain shipped in three directions from Canada, a boy wrote to the Winnipeg Grain Exchange for information. He received a prompt reply with the amounts of shipments from Fort William, Vancouver, and Churchill. Chambers of Commerce also respond graciously when specific information is requested. Travel agencies have provided literature and schedules which have made it possible for classes to compare distance, time, and cost of trips by air and water.

Field trips, taken in connection with the study of geography or elementary science, furnish many experiences involving number. For example, at the Food Terminal, the bulletin board and auction lists give numbers of car loads of produce received. At the ore docks in Cleveland Harbor, the class collects information concerning tonnage of various lake freighters, the time in transit from the upper lakes ports, and the time needed in unloading. Class members consult the Marine News of the daily papers and make a daily record of boats arriving and clearing the port of Cleveland. Each day's record is a row of small lake freighters, appropriately colored to indicate their cargoes. This pictograph is quickly made as a rubber stamp furnishes the freighter outline.

The children contribute problems using statistical data, as well as plans for graphs. By using a variety of number activities, much of the geographic information is made more understandable. Classes enjoy these activities, and the arithmetic problems which serve a purpose in the geography study are carefully solved. It is hoped that this type of quantitative thinking, if carried out consistently through the geography and other studies, will make the children more aware of number situations and will give them a clearer understanding of their meaning.

EDISON FOUNDATION INSTITUTE

Dr. Frederick M. Raubinger, Commissioner of Education, New Jersey State Department of Education and Vice Admiral Harold G. Bowen, Executive Director, Thomas Alva Edison Foundation, West Orange, New Jersey, announce their joint sponsorship of the Fourth Edison Foundation Institute to be held on November 24 and 25, 1952, at "Glenmont," Thomas Edison's home in Llewellyn Park, West Orange.

This joint Institute will explore ways and means for industry and education to work together at the elementary and secondary school levels to enable students to obtain a basic understanding of our industrial economy and its international impact, the fundamental role played by engineering and science in that economy and the need to encourage more high school students to choose careers in engineering and science. Fifty participants including industrialists, educators and civic leaders have been invited to attend this cooperative experiment in education.

CORROSION—THE GREAT DESTROYER OF METALS

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Since the days of the ancients man has relied on metals for tools, coins, ornaments, construction purposes, and a multitude of other uses. Some of these metals, such as copper, platinum, and gold are relatively immune to attack from moisture and atmospheric conditions to which they are exposed. However, the extensively used metal iron, and its alloy steel readily undergo corrosion, particularly in the presence of moisture. Metals may be exposed to materials and conditions much more corrosive than those nature furnishes. The chemical industry is a good example. Here pipe lines, pumps and other equipment are continually being called upon to withstand the attack of acids, alkalies, reactive gases, etc. Consequently, it is little wonder that although corrosion control is widely practiced, the estimated annual loss is so enormous, six billion dollars in the United States.

A large amount of information* is available and a great deal of experimental work has been done on corrosion but these efforts have only succeeded in reducing, not eliminating, metal losses due to this ever present destroyer. A knowledge of its nature and causes is essential for developing remedies.

MECHANISM OF CORROSION

Corrosive attack may be divided into two types:

1. Chemical attack by dry gases such as oxygen, chlorine or hydrogen sulfide.
2. Electrochemical attack. This involves moisture and is particularly apt to occur when the metal is immersed in water or some aqueous solution.

Type 1 may be illustrated by the scaling and disintegration that attacks the hot parts of a kitchen range. In a steel mill the scale formation on the surface of the hot steel during rolling is also of this type.

Type 2 is by far the more prevalent and, as a consequence, we will focus our attention on it. To understand the electrochemical nature of corrosion we must understand the basic principles of a voltaic cell, familiar examples of which are the dry cell and the lead storage battery.

In these cells electricity is produced by the electrochemical reactions at the two electrodes. The zinc container of the dry cell reacts to produce zinc ions and electrons. The electrons then pass through the external circuit to the carbon electrode. Here the electrons are

* See Bibliography.

taken up by the manganese dioxide in the cell. The important fact to remember is that corrosion by cell action always consists of two parts, the anodic and the cathodic. In the above cell the transformation of the zinc is an anodic process while the action at the carbon electrode is a cathodic process. The distinguishing feature of anodic action is the liberation of electrons, that of cathodic action, the taking on of electrons. In corrosion anodic action results in the formation of metallic ions. Pitting, the noticeable part of corrosion, takes place at the anodic areas as it is here that the metal is eaten away due to the loss of metal as ions. Cathodic areas are also necessary if corrosion is to occur. Here electrons, furnished by anodic action, are used in the discharge of hydrogen ions, or in the reaction of oxygen from the air with water to form hydroxyl ions. The metal always remains intact at the cathode. A variety of factors determine which areas will be anodic and which cathodic. Some of these will be discussed later.

In the case of iron immersed in acid, at the anodic spots the iron forms ferrous ions, the electrons liberated travel through the iron to the cathodic areas and are taken up by hydrogen ions which form hydrogen gas. The equations for the reactions at the two electrodes are as follows:

At the anode:

$$Fe \rightarrow Fe^{++} + 2e.$$

At the cathode:

$$2H^{+} + 2e \rightarrow H_2.$$

The more common situation is iron corroding in water containing oxygen. The anodic behavior is the same as above but at the cathode the previously mentioned reaction involving oxygen occurs. The equation follows:

$$O_2 + 2H_2O + 4e \rightarrow 4OH^{-}.$$

The formation of rust is explained by the ferrous ion being oxidized to the ferric form which then reacts with the OH^{-} ion to form ferric hydroxide and subsequently decomposes into ferric oxide. The equations are as follows:

$$4Fe^{++} + O_2 + 2H_2O \rightarrow 4Fe^{+++} + 4OH^{-}$$

$$Fe^{+++} + 3OH^{-} \rightarrow Fe(OH)_3$$

$$2Fe(OH)_3 \rightarrow Fe_2O_3 + 3H_2O.$$

Early corrosion theories considered rust formation in the presence of water to be direct combination of iron with oxygen as in the Type 1 variety of corrosion. This, however, fails to account for pitting, for

the action of moisture in accelerating corrosion, and for various other phenomena that are readily explained by the electrolytic theory.

Factors which Affect Corrosion

The tendency to corrode is closely associated with the potential created by the corrosion cell. Going back to the dry cell analogy, the potential is measured by the voltage this cell creates. As will be seen later, the voltage of a corrosion cell can also be measured. This voltage is a measure of the driving force of the corrosion reaction. A particularly good illustration of this factor is the effect of metal couples on the acceleration of corrosion. Iron in contact with copper or certain other metals is an example of a couple. These combinations cause iron to corrode much more rapidly than iron alone. The copper acts as a cathode and creates a considerable potential in contact with iron which is reflected in an increased corrosion rate over that of iron alone. Thus for corrosion prevention it is important to avoid contact of iron with metals to which it is anodic.

One generally can determine which metal of a couple will be the anode and the tendency of the couple to undergo corrosion by consulting the E.M.F. or Galvanic Series. This series is given in Table 1.

Table 1. Galvanic Series of Metals and Alloys

Pitted End (Anodic or least noble)
Magnesium
Zinc
Aluminum 2S (An alloy)
Cadmium
Iron or Steel
Cast Iron
Chromium—Iron (Active)
18-8 Chromium—Nickel—Iron (Active) (An alloy)
Lead—Tin solder
Lead
Tin
Nickel (Active)
Brasses
Copper
Bronzes
Copper—Nickel
Nickel (Passive)
Chromium—Iron (Passive)
18-8 Chromium—Nickel—Iron (Passive)
Silver
Gold
Platinum
Protected End (Cathodic or most noble)

It differs from the E.M.F. table found in texts since it is designed

particularly for corrosion work. It therefore includes both metals and their alloys.

The metal highest in the series is usually the anode in a cell. In addition, the higher in the series the anodic metal is, the greater should be its tendency to corrode. In actual cases of corrosion the table is not too reliable a guide in predicting which metal will be the anode in a couple, or the tendency of an anodic metal to corrode. Iron may become anodic to zinc in hot water systems and to aluminum in fresh water. In fruit juices tin becomes anodic to iron. Aluminum and magnesium, although high in the series, are resistant to corrosion due to the protective coatings they form. These illustrations serve to show that, as is often the case in corrosion phenomena, the factors controlling a particular case of corrosion are so numerous that the results can not be predicted on the basis of one of these factors.

The corrosion rate increases rapidly with increasing hydrogen ion concentration or decreasing pH. As iron and steel are attacked even by weak acids, special materials such as plastics and alloys must be used to handle them. Thus carbonic acid liberated from the bicarbonates in water, while it is being transformed into steam in a boiler, causes severe corrosion in steam and return lines.

As mentioned in the explanation of the mechanism of corrosion in acid solution, hydrogen is discharged at cathodic areas. If iron is in contact with any one of a number of metals, the latter furnish additional cathodic areas and serve to accelerate the liberation of hydrogen. For example, an iron rod immersed in acid liberates hydrogen, but the rate of evolution of the gas increases when the rod is touched with copper. The surface of the copper becomes coated with hydrogen which is produced by the reaction of hydrogen ions with electrons from the iron. Thus the rate of corrosion of the iron is increased by a catalytic effect of the copper which remains unattacked.

The role of oxygen in corrosion was outlined during the explanation of the electrochemical theory of corrosion. It thus should readily be seen that, other factors remaining constant, the rate of corrosion depends on the amount of oxygen coming in contact with the metal undergoing corrosion and that the oxygen type of corrosion accounts for the majority of the corrosion losses since most waters are not acid enough to cause hydrogen type corrosion.

One variation of this type of corrosion is the oxygen concentration cell. Here one part of the corroded object is exposed to a higher oxygen concentration than another. This causes corrosion to occur more rapidly below the water line than at it, and a steel screen to be attacked more at the joints than between them.

An interesting exception to the relation of oxygen concentration to corrosion is the case of iron-chromium alloys where rate of corrosion

decreases with increasing oxygen concentration. This is explained as due to the formation of a thin oxide film which is adherent and protects from further corrosion.

Theoretically a uniformly pure metal should be less subject to corrosion, as areas with different composition aid in establishing anodic and cathodic areas. Purifying iron does not increase its resistance to corrosion, but aluminum, magnesium and zinc corrode much less when pure; zinc containing 0.0001% impurities resists corrosion for months while 99.9% zinc corrodes more rapidly. Impure magnesium corrodes 100 to 500 times as fast as the pure metal.

Not only chemical but physical uniformity is helpful in retarding corrosion. Stresses in certain areas may be brought about in metals by pounding or working them. The stressed part is usually anodic. Stresses may be removed by heating, which then decreases the tendency of the metal to corrode.

Corrosion Prevention

Obviously, if any of the previously mentioned factors which cause corrosion can be restricted or eliminated, we are on the road to corrosion prevention. In this section we shall discuss the means of accomplishing this.

Use of metals and alloys less subject to corrosion than iron is a very important method of reducing corrosion losses. Copper, aluminum, magnesium, stainless steel, monel metal, duriron and others are commonly used. For special purposes, where more corrosive conditions are encountered, the more noble and also more expensive metals such as gold, silver, tantalum, iridium and platinum are used. Tables are available from various sources[1] which list the resistance to corrosion of many metals and alloys to various media.

Titanium, a newcomer to the field of useful metals, performs better in contact with salt water than almost all other metals and alloys. It is stronger than aluminum alloys, can operate at higher temperatures and is only half as heavy as steel alloys.

A wide variety of metals may be coated on iron and steel to increase corrosion resistance and there are a number of methods available for applying the coatings such as dipping, electroplating, metal spraying and others.

The position of the metal in the galvanic series is involved in the use of coatings, for if the coating has a hole in it or is worn away, we have a metal couple. Metals which are above iron in the series, for example zinc, protect under these conditions since they are anodic and are eaten away while the iron, being cathodic, remains intact.

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[1] Rabald, Erich, *Corrosion Guide*, Elsevier Publishing Co., New York, 1951.

This sacrificial type of protection is similar to cathodic control which will be discussed a little later. Copper, which is below iron in the series, and therefore cathodic to it, accelerates corrosion when the anodic iron becomes exposed after its copper coating is damaged. Since zinc protects even though the coating is porous, it can be applied as a thinner coating than copper which must be non-porous to be effective.

As an anodic coating, such as zinc, is gradually used up in protecting the iron, more and more of it is exposed. This leads eventually to the attack on this exposed iron. In fresh water the zinc must be 0.25 inch from a spot in the exposed area to protect it completely. In salt water this distance may be as great as several inches. This is due to the fact that salt water has a much higher electrical conductivity than fresh water. The same reason partially explains the more rapid corrosion of iron in salt water than in fresh water.

Numerous nonmetallic coatings are available which prevent or retard corrosion. Besides the familiar paint, lacquer, and porcelain enamel coatings there are newer developments, a few of which follow. A phosphate coating may be applied by dipping it in manganese acid phosphate solution. This is called Parkerizing or Bonderizing. A rubber coating may be applied to metal by electrophoresis, a process similar to electrolysis. The metal is made anode from which the procedure takes its name, anode process. The aluminum anodizing process produces, by electrolysis, a thin layer of aluminum oxide on the aluminum which protects the metal and improves its appearance. The anodized layer can be dyed to produce beautiful iridescent colors on the aluminum. Directions for an experiment demonstrating anodizing are available.[2] As previously mentioned, aluminum also forms a natural, protective oxide film which explains the corrosion resistance of this otherwise reactive metal.

Recalling the principles involved in the oxygen type of corrosion it is evident that corrosion can be retarded by reducing the oxygen content of the water in contact with the iron being attacked. In high pressure steam plants it is desirable to have the oxygen concentration as low as 0.005 P.P.M. In cold water lines rusting can be avoided by reducing dissolved oxygen to 0.3 P.P.M. Oxygen may be removed from water by de-aerators, by passing it over scrap iron or by treating it with sodium sulfite. The sulfite is often used to remove the last traces of oxygen. Its rate of oxygen removal can be increased by the use of catalysts such as salts of iron, copper, manganese or nickel.

The passivity of iron, aluminum, and copper in strong nitric acid is an apparent exception to the general rule that oxygen or oxidizing

[2] Shooner and Godard, "Formation of Anodic Films, A Lecture Demonstration," *Journal of Chemical Education*, 25, pp. 340–341, 1948.

agents in solution accelerate corrosion. Strong nitric acid may be stored in aluminum or iron containers although both metals are readily attacked by a more dilute acid. Other oxidizing agents also have the ability to make metals passive. Passivity is generally considered to be due to the formation of a protective film of oxide on the metal to be made passive. Referring to the Galvanic Series table, it will be noticed that some metals and alloys appear a second time in the passive form and, as would be expected, they are then less active as indicated by their position.

Numerous corrosion inhibitors are available. For example, sodium chromate may be used against such corrosive solutions as refrigerating brines containing sodium or calcium chloride. Inhibitors function somewhat as passivating agents do, by forming a film over the anodic or cathodic areas. When chromates are used with iron, a mixture of chromium and iron oxides forms on anodic areas. A good example of a cathodic inhibitor is the deposition of calcium carbonate from hard water on cathodic areas due to the increased alkalinity caused by the formation of hydroxyl ions. If insufficient anodic inhibitor is used, some anodes may remain active and corrosion will concentrate at these locations. Reduction of the number of cathodes by use of a limited amount of cathodic inhibitor is obviously not harmful since the metal is unattacked at the cathode.

If the metal exposed to a corrosive environment could be made entirely cathodic, it would not be attacked. This can be accomplished by a method called cathodic control, using one of the two following plans:

1. The metal to be protected is connected to an electrode made from a more active metal such as zinc or magnesium when iron is the metal protected.
2. A small, direct current is caused to flow between the protected metal which is the cathode and an inert electrode such as graphite.

Magnesium anodes are used for protecting pipe lines, boilers, hot water heaters, etc. The annual corrosion loss suffered by the nation's quarter million miles of pipe lines amounts to two hundred million dollars. Magnesium anodes are buried at intervals along a pipe line and connected to the line. Along coated lines the anodes may be spaced from 1000 feet to several miles apart. In the case of hot brine lines, anodes are installed every ten feet.

When the second plan is used the electrical current, which must be supplied, makes the installation more complicated. However, the graphite electrodes remain intact in contrast to the magnesium or zinc electrodes which gradually corrode away and must be replaced.

Corrosion Demonstration Experiments

One of the best ways to demonstrate the electro-chemical nature

of corrosion is by use of the ferroxyl reagent[3,4]. Prepare a 1.5% solution of agar agar by boiling the agar gently with the required amount of water for half an hour. It is preferable to filter the hot agar through cloth or glass wool to clarify it. Add a few drops of phenolphthalein indicator solution and 5 ml. of a fresh, 1% solution of potassium ferricyanide to every 100 ml. of the agar solution. Pour some of the solution into a petri dish or other flat container and allow it to harden. Hardening may be hastened by cooling in a refrigerator or in cold water. Place on the hardened gel the iron or steel specimens to be observed, nails, screws, washers, etc. Pour over the objects another layer of hot agar solution. In a surprisingly short time corrosion progresses enough for its effects to be visible. At the anodic areas blue ferrous ferricyanide is formed according to the following equation:

$$3Fe^{++}+2K_3Fe(CN)_6 \rightarrow Fe_3[Fe(CN)_6]_2+6K^+$$

At the cathode the OH^- ions formed turn the phenolphthalein pink. A nail usually produces the blue ferricyanide at the head and tip, a washer on the edge, a screw along the threads, all points of strain which produce an anodic condition.

A similar experiment is available for demonstrating the corrosion of aluminum.[5] To the hot agar solution, made as before, add the following to each 100 ml: 1 g. of sodium chloride, 13 ml. of 0.1% aluminon reagent and 13 ml. of 0.05% thymol blue indicator solution. The agar is adjusted to a pH of 8 by adding dilute sodium hydroxide. Pieces of aluminum are embedded in the gel as in the case of the ferroxyl experiment. Anodic areas become pink, cathodic are blue.

An oxygen concentration cell can be shown as follows. On a flat iron surface place a drop of salt solution containing ferroxyl reagent. The blue anodic area appears in the center of the drop the pink cathodic areas around the edge. The areas around the edge receive more oxygen and are thus made cathodic.

To show that a difference in potential exists between metal objects undergoing corrosion, connect metal objects immersed in salt solution to a lecture type voltmeter or other sensitive voltmeter. A pair of nails or a nail and a piece of aluminum may be used. By this means one can determine which metal is anodic and from the magnitude of the voltmeter reading obtain a rough idea of the corrosion rate.

Numerous simple demonstrations can be used to illustrate the affect of various factors on corrosion. As a control, put iron objects in

[3] Meldrum, Wm., "Demonstrations Using the Ferroxyl Reagent," *Journal of Chemical Education*, 25, pp. 254-255, 1948.

[4] Orr and Stafford, "Theory of Corrosion for Engineers," *ibid.*, 27, pp. 202-208, 1950.

[5] Orr, Wilson, "Demonstration Reagent for Corrosion of Aluminum," *Journal of Chemical Education*, 26, pp. 267-268, 1949.

tap or distilled water and contrast the amount of rust formed by that produced with salt solution, salt solution containing inhibitors, salt solution acting on iron connected to zinc or magnesium. These demonstrations require some time, perhaps several months to show pronounced effects.

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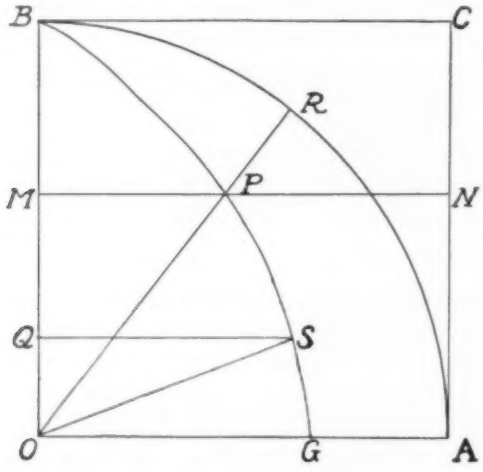
THE QUADRATRIX, A SIMPLE BUT REMARKABLE CURVE

R. F. GRAESSER

University of Arizona, Tucson, Arizona

Has the quadratrix been properly appreciated? It seems to be a most remarkable curve, for it may be used not only to trisect any



angle but to divide any angle into any number of equal parts. Besides this, it may be used to square the circle thus solving two of the three famous geometric problems of antiquity. It is the only curve that will solve more than one of these problems. Finally, it is a very

simple curve in its construction, and the fact that it was discovered, together with a knowledge of the above properties, about four hundred years before Christ makes it seem even more remarkable. It is attributed to Hippias of Elis, a Sophist, who is said to have made a special study of geometry. To obtain the curve, let the radius OR of a circle rotate through a right angle about its center O from the position OA to the position OB, the rotation to take place at constant angular velocity. While this is happening, let the line MN, which remains always parallel to OA, move with constant velocity from the position OA to the position BC. The locus of the intersections of MN with OR is the quadratrix GPB.

Now let angle AOP represent any angle. In order to trisect this angle, draw PM parallel to OA. Trisect the segment MO at Q, and draw QS parallel to OA and intersecting the quadratrix in S. Then

$$3\angle AOS = \angle AOP.$$

To divide angle AOP into n equal parts, divide MO into n equal parts and proceed as before.

Now let P be any point on the quadratrix whose polar coordinates are r, θ, O being the pole and OA coinciding with the initial line. Also let OA equal a. Then, by the method of constructing the quadratrix, we have the proportion

$$\theta \div (\pi/2) = (r \sin \theta) \div a,$$

or

$$r = 2a\theta/\pi \sin \theta,$$

which is the equation of the quadratrix. To determine the point G where the quadratrix intersects OA, let θ approach zero. Then OG equals $2a/\pi$, since the limit, as θ approaches zero, of $\theta/\sin \theta$ is equal to one. Hence a quarter circle of radius OG has the length OA, and we have solved the quadrature of the circle.

Science has no nationality because knowledge is the patrimony of humanity, the torch which gives light to the world.—Louis Pasteur

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Chrome-protecting fluid reduces corrosion on automobile trimming, particularly chrome trim on late-model cars that has little or no nickel mixed in due to current restrictions. Complete with dauber, the liquid dries in 12 minutes, cures completely in 48 hours and should form a coating good for six months.

Perfumed plastic is used in shower and window curtains to give the fragrance of a flower garden. Available in a variety of colors, the curtains' perfume is not sprayed on but is an integral part of the fabric.

FURTHER "EXPLORATIONS" IN SPACE

JULIUS SUMNER MILLER
Ford Foundation Fellow, Department of Physics University of California, Los Angeles, California

My earlier essay in this journal on rocket ships and space travel has provoked some discussion and inquiry. I find it difficult to reply to all the inquirers individually and more difficult still to answer explicitly all the singular questions which they have put. Accordingly, I take this means of giving my reflections on some of the problems which readers have presented. If I fail to answer some it is hoped that the reader will do some interpolation and extrapolation of his own and thus arrive at some approximate answers for himself.

First, I firmly *believe* that these things will be accomplished; not right away, you understand, but within the lifetime of some of you who are now reading these lines. Some of the issues are indeed troublesome, but on these my guess is this: that utterly fantastic achievements will be made—achievements *now* hopelessly beyond our imaginations. Were not modern-day wonders once thought sheer madness?

Let us now go to the Moon. We have the spaceships to use as bases. From these explorers will set out for the Moon in some kind of space-suit. What these space-suits* will be like is problematical, but a few requirements are clear: If they are flexible they will have articulated joints like man himself possesses. The gravity problem will not be great, for g on the Moon is about six times less than on Earth. They may, however, be totally inflexible, like a diving-bell. They will then have "limbs," like legs and arms, activated by motors. Regarding locomotion, we Earth-bound creatures are given to think of it in terms of legs, although there may be better ways of getting about! Whatever the suits, we must provide air to breathe, but this is a minor problem for tanks of it can be carried along. A much severer problem is temperature control. On the Moon, you will remember, the transition from scorching heat to freezing cold—a change, maybe, of 4 or 5 hundred degrees, can be achieved in a split second by moving across the shadow line. *This* is a very serious business, and our explorers had better watch where they tread! The suits could be insulated, like a thermos jug, but we must not forget that the body-heat must be dissipated. There is trouble, you see, whether we try to keep the heat in or the heat out. It looks as if we will have to have a cooling system within the suit. This will handle *that* problem.

* We are not yet agreed on even the spelling of these new words!

Now how will the men communicate with each other, we are asked? This struck one reader as a problem since there is no atmosphere on the Moon and hence no medium for sound transmission. No problem at all: radio.

How about living quarters while exploration goes on? We'll build a base on the Moon. By the time this problem arises we will have new materials on Earth easy to transport and easy to handle. Maybe the same stuff the space-suit itself is made of. And like the suit it will be insulated and refrigerated. Where will it be put? Obviously on the lighted side of the Moon; maybe in one of the large lunar craters. It will *always* be within Earth-sight, won't it? And we will stock it with supplies from our space planet.

So we have a Moon-base established. We turn our attention to developing the resources of our new Moon-dwelling. Is not that what men do on Earth? This, indeed, is how cities came to be. So let's explore the possibilities. We need water. There is none on the Moon, we are told. My own guess is that there might be some on the cold side of the Moon—in the solid state. We will carry it over and the heat available on our side will convert it quickly to potable water. Further: there may be water within the crust of the Moon, trapped in the rock. If we mine the crust and expose the water-bearing ore the sun's heat will free it. All we need to do then is condense it. A moment in the cold zone will do that. We shall probably have distillation plants and condensers. On the other hand it just occurs to me: Can't we *siphon* water over the Moon? Of course we can.

How about oxygen? We will either pipe it to the Moon or extract it from the rock there? This last could be done by utilizing the sun's heat or atomic energy. We now have the two essentials—air and water—which Earth Dwellers require. Parenthetically: after some centuries of evolutionary process I believe we can develop a new species which will not need air and water!

How about food? We will have chemical synthesis. We have that now. And we might well be able to establish some vegetation which will flourish on the Moon.

Finally, lest you think we have already gone off the deep end, be reminded of this: there is no longer any question of whether these things *can* be done. The question now is: how? As I have said before, anything the human mind contrives can be accomplished. I am painfully anguished by the thought that I shall not be here to see these things.

Learning, undigested by thought, is labor lost; thought, unassisted by learning, is perilous.—CONFUCIUS.

SUGGESTED TOPICS FOR PROJECTS IN PHYSIOGRAPHY AND PHYSICAL SCIENCE

LOUIS PANUSH
Northeastern High School, Detroit, Michigan

Physiography, or *Earth Science*, as taught in most of the academic high schools in Detroit is a one-semester course which either may be elected separately for five hours credit (one-half unit) or together with Physiology to constitute a unit credit in non-laboratory science as a requirement for graduation. At Central High School, where the author has taught a class in physiography for a number of years, the course was elected primarily by 11th and 12th graders who already have had at least one year of previous laboratory or non-laboratory science training. It was popular with both college and non-college preparatory students, with boys as well as with girls, with graduating seniors as well as with lower classmen. It was a purely elective course which appealed to many students.

The following statistics, compiled for four classes for the years 1948–1950, seem to bear out the statements made above. Of the 135 students who have elected the course, 56% were boys, and 44%—girls; 44% were 12A's; 66% were college preparatory students, 18%—general and 16%—commercial. All of them had previous training in science courses: 60% in laboratory sciences (biology, and/or chemistry, and/or physics) and 40% in non-laboratory courses (physiology, general biology, and physical science). Only 6.6% had failed and 3% had earned the grade of A in a previous c.p. science course. It is also interesting to note the distribution of grades earned in physiography by these students: 15% received A's, 37%—B's, 25%—C's, 20%—D's, and only 3% failed in the course.

Although it is not the intention of the writer to present in this paper a justification for placing and keeping physiography in the high school curriculum,[1] he cannot but stress the fact that in his opinion, and as a result of his experience in teaching it, this course is definitely worthwhile for it provides good, interesting and stimulating educational experiences for students of different backgrounds and of varying abilities and interests. Physiography is so rich in content, in materials, in audio-visual aids, in laboratory experiences and in opportunities for out-of-classroom activities, that it could easily be offered as a full-year laboratory course in science, as an elective and not as a requirement or as a substitute for other full-year laboratory courses. It certainly would be much more worth-

[1] For an excellent justification of the place of physiography in the high school curriculum, read "The Teaching of Earth Sciences in Secondary Schools" by G. P. McGrath in the *Metropolitan Detroit Science Review*, Vol. XI, No. 2, December, 1950, pp. 12–15.

while than the courses in so-called physical science as they are offered in a number of our high schools today.

Since his classes consisted of a variety of students, of different I.Q.'s and scientific backgrounds, and of varying interests and capabilities, the writer found the use of projects, term papers, and other supplementary materials very helpful and of definite educational value in teaching this course. He has discussed elsewhere[2,3] the reasons for requiring projects and term papers and the procedures used in assigning, selecting, and integrating the students' contributions with class and laboratory work. His purpose here is to present a list of suggested topics for term papers which his students have used with varying degrees of success, in the hope that teachers of physiography and of physical science (the latter could expand it with suitable topics in chemistry and physics) and their students will find it a helpful and satisfactory source and guide for term papers and for class reports.[4] The list is divided into the major subject areas of the course: Astronomy, Geology (including Mineralogy), and Meteorology. It is presented, however, with the understanding—as it is in the actual teaching of physiography in the classroom—that it is a unified subject in which emphasis is placed upon the effects of geologic processes, spatial relationships and atmospheric phenomena upon man and his daily life.

ASTRONOMY

*Our Solar System
The Milky Way
Other Solar Systems and Galaxies
*A Study of Our Sun
*A Study of the Moon
*A Study of Mars
*The Planets Beyond Mars
*Lunar and Solar Eclipses
*Meteors and Meteorites
Variable Stars, Novae, and Spiral Nebulae
Stars of the Summer Night
Constellations of Wintry Heavens
*Day and Night
*Seasons on the Earth and Their Causes
*The Story of Rockets
Will Space Be Conquered?
Interplanetary Travel—Science and Fiction

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[2] "Term Reports in Earth Science," by Louis Panush. *The Science Teacher*, Vol. XVIII, No. 1, February, 1951, p. 25.

[3] "How to Use Projects in Teaching High School Chemistry," by Louis Panush. SCHOOL SCIENCE AND MATHEMATICS, Vol. LII, No. 4, April, 1952, pp. 291–299.

[4] For additional suggestions and information on materials which will be helpful in enriching the teaching of physiography such as text references, magazines for the teacher and the student, magazine references to the major subject areas, and demonstration materials, visual aids, and suggested projects (other than term papers), see "Earth Science Source Materials," part I by Louis Panush, *The Science Teacher*, Vol. XVIII, No. 5, November, 1951, pp. 236–238.

* Starred topics seemed to appeal most: they were more frequently chosen by students for their term reports.

Some Famous Observatories in the United States
Some Famous Observatories of the World
A Brief History of Astronomy
*The Story of the 200-inch Telescope
*The Contributions of Copernicus—Tycho Brahe—Kepler—Galileo—Newton—Halley—Herschel—and others
Famous Contemporary American Astronomers
Instruments for Solar Research
How to Build a Telescope
*The Story of Our Calendar
*Time Zones of the World
Theories on the Origin of Planets
*The Story of Keeping Time
The World Calendar

Geology and Mineralogy

*The Origin and Age of the Earth
The Earth's Interior
A Brief History of Life on Earth
*A Brief Geologic History of the Earth
*Practical Applications of Geology
*The History and Geology of the Great Lakes
*Commerce on the Great Lakes
The Geological History of Your State
A Study of Local Topography
*A Study of the Recreational Areas of Your Community
*A Study of the Water Supply and Its Purification in Your Community
Pollution of Inland Waters and Methods of Control
*Methods Used to Control Soil Erosion
Crop Rotation and Soil Conservation
Colorado, A Study of Weathering and Erosion
The Valley of the Rio Grande River
The Valley of the Nile
*The Valley of the Yangtze
The Valley of the Tigris and Euphrates
The Valley of the Rhine
*The Mississippi Delta
*The Badlands of South Dakota
*The Black Hills
*The Story of the Appalachian Mountains
*The Story of the Rockies
The Story of the South American Andes
The Story of the Himalayas
Utilization of Mountains and Hills
The Columbia Plateau of the United States
*The Grand Canyon of the Colorado River
The History of the Mississippi River
Volcanic Cones in the United States
*Some Famous Valcanoes of the World
*The Birth of a Volcano, Paricútin
*Rocky Mountain National Park
*Yellowstone National Park
*National Parks I Have Toured
Great Dust Storms in the United States
The Shoshone Dam and Irrigation Projects
*The T.V.A.
*The Grand Coulee Dam
*The Story of the Panama Canal

One Hundred Years of Engineering in the United States
The Mineral Wealth of the Seas
Hot Springs and Mineral Springs Health Resorts
Famous Falls of the World
*The Niagara Falls
*The Great Salt Lake
*The Negev in Israel and Its Reclamation
*The History and Geology of the Dead Sea
*Great Deserts of the World
The Story of the Sahara Desert
Adventures in the Gobi Desert
The National Forests of the United States
*Forest Fires: Origin, Prevention, Control
Famous Caves
*The Mammoth Cave and Carlsbad Caverns
Life of a Glacier
The Greenland and Antarctic Glaciers
Earthquakes in Japan
Earthquakes in North America
*The San Francisco Earthquake
*The Story of Krakatoa
*Vesuvius
*The Seismograph: Construction, Working and Application
Forests as Crops. Forest Conservation Methods
Irrigation Principles and Methods
*The Story of Coal
*The Story of Diamonds
*Asbestos, the Magic Mineral
*Precious and Semi-precious Stones
*The Story of Sulphur
*The Story of Oil
Oil Centers of the United States
New Oil Fields in Canada
Natural Gas and How It Is Piped Across the Continent
*The Story of Aluminum
*The Story of Iron
The Messabi Range of Minnesota
*From Iron to Steel
*The Story of Copper
*The Keeweenaw Peninsula
Silver and Gold Mining in the United States
Present Mineral Resources of the United States
*Famous Mining Towns
Our Oil and Coal Reserves
Strategic Minerals in World War II
*The Story of Salt
*Radioactive Minerals
Prospecting for Uranium Ore
Conversion of Shale Oil Into Petroleum Products

METEOROLOGY

*The U. S. Weather Bureau
How Is Weather Forecasted?
The Climates of the United States
*Techniques of Observing Weather
*Instruments for Measuring Air Pressure
Methods of Testing Air for Relative Humidity
Origin and Characteristics of Air Masses
Recent Development in Air Mass Analysis

*Recent Studies of the Stratosphere
Recent Studies of the Ionosphere
*Aviation and Weather
*Adventures in Ballooning
*Famous Hurricanes and Tornadoes
The Monsoon Winds of India
The Coriolis Effect
*The Atmosphere as a Geologic Agent
*Clouds and Their Meaning
*Dew, Frost, Rain, Hail, Ice, Storms, Thunderstorms
*Hurricanes, Their Nature and History
Weather Maps and How to Read Them

MISCELLANEOUS TOPICS

The American Museum of Natural History
*The Smithsonian Institution
*A Visit to a Planetarium (Adler's in Chicago; Hayden in New York, etc.)
*The Cranbrook Institute of Science
The Oceanographic Institute at Woods Hole, Cape Cod
*Limestone and Its Uses
Portland Cement, Its Manufacture, Composition and Uses
Clay and Its Uses
Plant Fertilizers of Mineral Origin
*Buried Cities
The Roads of the Incas
The Island of Hawaii
*Prehistoric Monsters
*Prehistoric Man
Famous Explorers
*Mountain Climbing and Famous Mountain Climbers
The Story of Agriculture
*Rubber Plantations in Malaya and East Indies
The Story of Coffee
Life in the Amazon Basin
Food for the World
*Wood Pulp and Paper Manufacturing in the U. S.

1952–53 TEACHING AIDS CATALOGUE AVAILABLE

A revised 19-page Teaching Aids Catalogue for 1952–1953 is available from the Westinghouse Electric Corporation's School Service Department. Introducing a section on home lighting pamphlets along with other new classroom aids, the catalogue describes 84 free or low-cost booklets, charts, posters, and other audio-visual aids available to junior and senior high schools.

In addition to home lighting, these aids cover a wide range of subjects including science, social studies, agriculture, home economics, industrial arts, and photography. The catalogue also has sections on audio visual aids, lighting the school plant, technical publications, Westinghouse scholarships available to students and teachers, and information on the Company's Five-Year Replacement Plan on appliances in home economics laboratories.

The catalogue contains order blanks for use in requesting desired materials.

Copies of this Teaching Aids Catalogue (B-5784) can be obtained by writing to the School Service Department, Dept. T-359, Westinghouse Electric Corporation, P. O. Box 2278, Pittsburgh 30, Pa.

SCIENCE FAIR? HERE'S HOW!

STUDENTS OF DR. JOHN READ
School of Education, Boston University, Mass.

A science teacher attending a science fair is attracted by its tremendous benefits in experience and inspiration to its student participants. He is tempted to conduct his own, yet is appalled by the many problems that such a venture presents. If there were only somewhere that he could turn for help.

Most science teachers are possessed of enough ingenuity and intelligence to operate a fair, yet few have the necessary over-all picture

SCIENCE FAIR

that is necessary to permit the smooth functioning of the undertaking. We, as a group of science teachers in Dr. John Read's seminar, knowing from experience something of fairs, decided that if we could do anything to help our colleagues in the solution of this problem, then that help could best be directed to the compiling of a Science Fair Brochure.

Our committee searched through many sources of information relative to the operation of a science fair. We received much generous assistance from many groups and individuals. Monumental work was performed in the compiling, sorting and adaptation of information

received into usable form. Finally division of labor and individual specialization solved the complex problem and each committee member contributed a portion of this rather extensive brochure.

It is not the purpose of this report to reproduce here the brochure that we have prepared. Rather its purpose is to inform the reader what he can expect to find in the brochure in the event that he wishes to obtain one.

Consider where to hold the fair. It is necessary to take into account utility outlets, space and traffic control. Many possible locations could provide conditions which might be suitable such as cafeteria, gymnasiums, auditoriums, corridors or classrooms. Each area selected demands different problems to be solved.

Financing the fair. We have suggested many ways to get the money. Some of the sources are through newspapers, merchants, professional organizations, school amateur theatricals and musicals, the sale of food, and collection of junk.

Identity of the Committee Members in this Picture. *Left to right:* 1. Herbert Oxendine, School of Education, Boston University, 2. Carl F. Bowman, Acton High School, West Acton, Mass. 3. Robert MacCurdy, Watertown Senior High, Watertown, Mass. 4. Everett F. Learnard, Norwood Sr. High School, Norwood, Mass. 5. Charles N. E. Howard, Lincoln Jr. High, Malden, Mass. 6. Dr. Renato E. Leonelli, R. I. College of Education, Providence, R. I. 7. Dr. John G. Read, Professor of Science Education, Boston University, 8. Christos Daoulas, Dracut High School, Dracut, Mass. 9. David A. J. Burns, J. M. Morton J. H. S., Fall River, Mass. 10. Bennie H. Patton, School of Education, Boston University. 11. Harold B. Bjornson, Malden High School, Malden, Mass.

Publicity for the fair is an important factor in its success. We discovered that community agencies will handle well-prepared releases. School art departments and school papers are easily able to assist and the duplicating and printing can be done in the school departments. A central agency for publicity work is recommended.

The rules for exhibitors are primarily concerned with safety and are

essentially ground rules to fit the local fair. We felt that they should be considered as such. We included many general suggestions.

The judges for the fair gave us a problem to solve. We established standards for their qualifications as a judge; suggested sources of judges; outlined a philosophy of judging; and promulgated etiquette for the treatment of judges. The score card itself was carefully prepared from what seemed to be the best points of all known score cards. After we re-evaluated the score cards, a new one was prepared and a sample included in the brochure.

Awards for the winners was a serious problem. This may make or break a fair by establishing the basic motivation. We examined many existing awards and award systems. Finally, we suggested a series of awards of increasing value as the size of the fair increased.

A list of possible exhibits for the fair was carefully prepared. It represents a search of many similar lists with careful examination of each possible exhibit and a final list made up of what appears to be the more challenging and advanced type of exhibits. There are one hundred Physical Science and one hundred Biological Science items.

A bibliography of science fair information sources was included in the brochure. We realized that we did not know all and that there are many valuable sources of Science Fair information. Many of these sources contributed to the building of this brochure. We listed about twenty such sources.

The brochure itself has been reproduced in considerable numbers. It is available on request from a source which will be revealed if the inquiring person will contact the authors. It is the sincere hope that those who contemplate the organizing and establishing of their own fair will find the brochure to be of considerable help in the solution of the many problems involved in such a procedure.

Dr. John G. Read, *Advisor*
Dr. Renato E. Leonelli, *Chairman*
Mr. Robert D. MacCurdy, *Secretary*

Mr. Carl F. Bowman
Mr. Harold Bjornson
Mr. David Burns
Mr. Christos Daoulas
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MAGNETISM

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CHAPTER I

The Natural Magnet or Lodestone

Historical.—Centuries before our present era, writers referred to a stone which possessed the property of attracting pieces of iron to it.

Fig. 1. Steel rings hang pendent from a piece of magnetite

In the celebrated, philosophical poem, De Rerum Natura, by the Roman poet Lucretius (95–55 B.C.), we find the term magnet used, together with a beautiful description of the powers which such a body possesses. Dr. Busby in his translation of this poem gives the follow-

ing words:

"Now, chief of all, the magnet's power I sing
And from what laws the attractive functions spring:
The magnet's name the observing Grecians drew
From the magnetic region where it grew;
Its viewless potent virtues men surprise,
Its strange effects they view with wondering eyes,
When, without hinges, links, or springs,
A pendent chain we hold of steely rings (Fig. 1)
Dropt from the stone—the stone the binding force—
Ring cleaves to ring, and owns magnetic force:
Those held superior, those below maintain,
Circle 'neath circle downward draws in vain,
Whilst free in air disports the oscillating chain."

FIG. 2. The shepherd, Magnes, Observes with astonishment the iron crook of his staff clinging to the face of the mountain

Here Lucretius is saying that the term magnet derives from the name of the place whence the material, which showed this marvellous attractive power, was obtained, viz., "in the native hills of the Magnesians"; hence it was called the Magnesian stone, or magnet. Pliny, who lived somewhat later than Lucretius (23–79 A.D.), gives us a lovely legend, as copied from the work of the poet Nicander (Second century B.C.), that a shepherd, Magnes by name, while tending his

flocks on the slopes of Mount Ida, was astonished to observe that the iron crook of his staff clung to the face of the mountain. See Fig. 2. Hence, from the name of the shepherd came the term Magnes Stone and our word magnet.

Bauer in his book *Principal Facts of the Earth's Magnetism* states that "The fundamental property of the Magnesian stone attracting iron was certainly known to the Greeks toward the close of the 7th century B. C., as it was mentioned by Thales, who lived between 640–546 B.C." Bauer goes on to say, "The Chinese are credited with the earliest knowledge of the attracting power of materials like

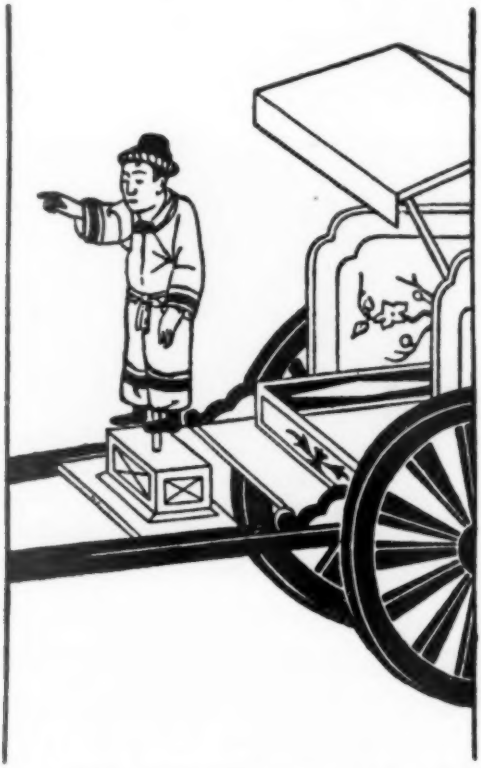

FIG. 3. South pointing cart (magnetic) used by the Japanese as early as the 7th century A.D.

the Magnesian stone. Tradition would even ascribe to them the knowledge of this drawing power as far back as the year 2634 B.C. A quaint legend says that in the 64th year of the reign of Ho-ang-ti (2634 B.C.) the emperor, Hiuan-yuan, or Ho-ang-ti, attacked the rebel Tchi-yeou, or Khiang, on the plains of Tchou-lou. Khiang getting the worst of the conflict, raised a great fog in order to throw the ranks of his adversary into confusion. Hiuan-yuan, however, was

equal to the occasion and constructed a chariot (Tchi-nan), *which indicated the south*, so as to distinguish the four cardinal points, and thus was enabled to pursue Khiang and take him prisoner." Many Chinese annalists regard it impossible to rely upon any records dating back more than 800 years before our era. Fig. 3 shows a south pointing cart as used by the Japanese in the 7th century A.D. for determining direction magnetically.

It is now known that the Magnesian stone was in all probability the natural mineral magnetite, the name originating as have the other words just mentioned. Magnetite is an oxide of iron. Sometimes its composition is given as (FeO, Fe_3O_4)[1] and sometimes just (Fe_3O_4), the latter being the chief constituent. It crystallizes in an octahedral form as shown in Fig. 4. Much of the magnetite showing natural magnetization is polycrystalline, not a single crystal as in Fig. 4.

FIG. 4. A crystal of magnetite

There are other minerals which show in lesser degree the magnetic properties of magnetite. Among these may be mentioned haematite (Fe_2O_3) and the sulphur compounds of iron such as ($6FeS\ Fe_2S_3$).

In the early knowledge of the Magnesian stone it was assumed that this attracting power which it possessed was due to an unknown fluid pervading the stone and which flowed from one end of the stone to the other, or could be subtracted or added to the material showing magnetic properties. Our present knowledge, however, denies any such hypothetical substance in the mineral, and so the term magnetism is given to this attracting power of magnetite, irrespective of how we explain this force. When we say that a body possesses magnetism we simply mean that the body has the power to attract iron

[1] Welo and Baudisch, *Phil. Mag.*, 3, 396, 1927.

in the same way as does the Magnesian stone. A body is said to be magnetized when it attracts small bits of iron as does magnetite.

The natural magnet appears to have been known in almost every country and at remote periods. The Talmud uses the term *nachzab'th*, the stone which attracts, and in their ancient prayers the Jews have the European name *magnēs*. The Chinese, for instance, use the word *thsee-schy*, or love stone. In the Sanscrit the magnet is termed *ayaskanta*, loving toward iron. Euripides calls the Magnesian stone *lapis Herculaneus*, the Herculean stone, from its power over iron. Because, as we shall see later, the Magnesian stone may be used for finding direction, the name for magnet has been developed with this property in mind. In Icelandic it is *leiderstein*, the leading stone after the Saxon of *laedan*, to lead, whence comes the common English term for the magnet—*lodestone*.

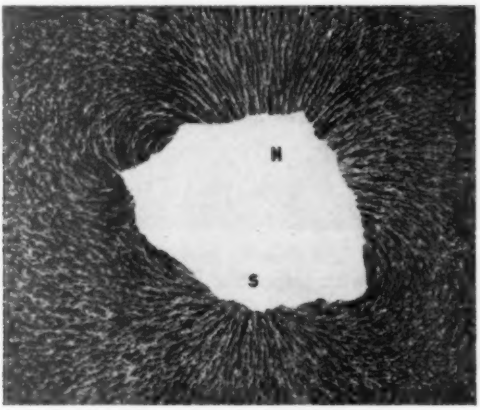

FIG. 5. Representation of the magnetic field about a piece of magnetite.

Magnetic Fields of Force and their Graphical Representation. A piece of magnetite possesses magnetism and all around the piece exists what is called a field of force. Theoretically it extends to infinity, but it is only a comparatively short distance away from the magnetite where this force of attracting small bits of iron can be detected. In order to visualize the field connected with a piece of magnetite, Michael Faraday (1791–1867) made use of so-called lines of force for depicting these magnetic fields. These lines of force are lines drawn about the magnetite which will represent the paths along which the magnetic forces operate. There are several ways for showing these lines of force. The first method to be described will be by means of scattered iron filings. Suppose we lay a piece of magnetite on a sheet of photographic paper in a darkroom, illuminated by a ruby light. Then scatter around the magnetite some iron filings. On sharply tapping the table on which the photographic paper and magnetite are laid, the

iron filings will begin to orient themselves along fairly definite lines. When the filings have been properly settled by tapping, an electric lamp is flashed over the photosensitive paper. Developing the paper after this flash gives a picture like that shown in Fig. 5. It will be noticed that the farther away we get from the Magnesian stone the less definite the lines appear. The field of force of the magnetite has tapered off to such an extent that it no longer has the power to align the iron particles. The iron filings are long, slender bits of iron, and when brought into a magnetic field put their lengths parallel to the field and thereby appear as lines which we call magnetic lines of force. These shadow pictures of the filings and the magnetite on a sheet of paper serve a useful purpose in showing us how the magnetic field is distributed about the mass of the magnetite.

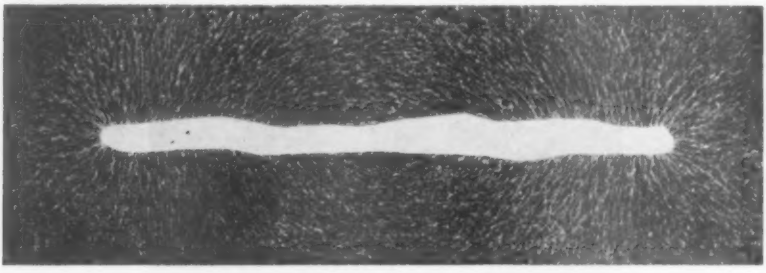

FIG. 6. Illustrating the field about a piece of magnetite whose length is large with respect to its cross section.

Magnetic Poles. The attractive power of the Magnesian stone seems to be concentrated in two points directly opposite each other, which are called the magnetic poles of the lodestone. These two points for the piece of magnetite shown in Fig. 5 are located not far from the two letters *N* and *S*. At least two poles are always associated with each piece of magnetic material. Fig. 5 indicates some subsidiary poles which we call *consequent poles*. It will be seen in Fig. 5 that in the vicinity of the poles (not sharply defined points) the magnetic lines of force are more condensed than anywhere else in the field. The poles are really the points where the resultant of all the magnetic forces act. These magnetic poles are more sharply defined the longer and slimmer the pieces of magnetite become. This can be seen by comparing the two fields of force illustrated in Figs. 5 and 6. Even though magnetic poles seem to be spread over considerable volume at the ends of the magnets, there is still one very specific point from which their resultant force emanates. The difficulty lies in locating these points with precision.

In connection with these magnetic fields associated with natural magnets, it is well to remember that they are fairly well fixed with respect to the pieces of magnetite with which they are associated. Un-

der certain conditions this field can be shifted by applying other powerful magnetic fields in different directions from that in which they are magnetized. In general, the magnetic field has a definite and fixed orientation for each lodestone with which it is associated. As a result, if the lodestone swings, its magnetic field swings also; or, if the magnetic field is made to turn, the lodestone follows.

Field Strengths are Vector Quantities. Any physical quantity which possesses both magnitude and direction is called a vector quantity. The field of force about a piece of magnetite will, at any definite point in that field, possess a definite magnitude and direction. Hence, a magnetic field strength may be represented by a vector, i.e., by a line whose direction is that of the field and whose length represents the magnitude of the field. These values of magnitude and direction will be defined later on.

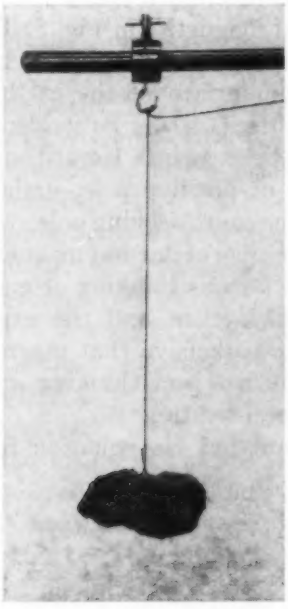

FIG. 7. A piece of magnetite, or a lodestone indicates direction and magnitude of magnetic fields

The Directive Power of the Lodestone. If a large block of magnetite like that in Fig. 5 is considered, it will have about it a magnetic field of force. In this field of force, suspend by a fine fiber, attached midway between the poles, an elongated piece of magnetite like that in Fig. 6 or 7. It will be found that for a given point in the field of the large piece of magnetite the suspended piece of magnetite will always set itself in a definite direction at that point. Notice that it will set itself fairly near to such a position that the straight line (magnetic

axis) drawn between the two poles of the swinging lodestone will be parallel to the direction of the field in which the lodestone is hung. A line drawn parallel to the axis of the swinging lodestone will be the direction of the magnetic field.

As we proceed we shall discover how very basic this behavior of the swinging lodestone in a magnetic field becomes for our modern theory of magnetism. Already we begin to see how the iron filings arranged themselves in Figs. 5 and 6. Each little filing is an elongated piece of iron which becomes a small magnet and sets itself parallel to the field in which it finds itself. Another fact appears as we regard the swinging lodestone. When the swinging lodestone is placed out in the open, away from any apparent source of magnetism, it still sets itself in a definite direction with respect to the surface of the earth, and we recognize the point, clarified by Gilbert in his justly famous book *De Magnete*, that the earth itself is a magnet and possesses a magnetic field as did the block of magnetite in Fig. 5. This, of course, leads to the idea that the suspended bar of magnetite has become a means for directing man over the surface of the earth, and, even more important, over the seven seas where no guideposts are present. That end of the lodestone which points toward, or seeks, the north, we call the north-seeking or positive pole, designated by N or by $+$, while the other end is the south-seeking pole, designated by S or by $-$.

Thus, as man's knowledge of natural magnets grew it became more and more evident that he was thinking of magnetic poles as fundamental concepts of magnetism and the explanation of magnetic phenomena. Man came to believe that magnetic poles were fundamental entities just as he had been thinking, and rightly, that electric charges were fundamental entities.

When Newton formulated his equation for the forces between masses, viz.

$$F = GM_1 \times \frac{M_2}{R^2}$$

he felt that the masses M_1 and M_2, and the distance R were fundamental units. In a similar fashion Coulomb enunciated his law for the forces which prevail between electric charges, viz.

$$F = e_1 \times \frac{e_2}{\epsilon R^2}$$

where e_1 and e_2 are the electric charges and R is the distance between them.

The next step made by Coulomb, however, led us into a lot of bad and often false thinking, when he formulated his law for the forces

between magnetic poles, viz.

$$F = m_1 \times \frac{m_2}{\mu R^2}$$

where m_1 and m_2 are the magnetic poles and R is the distance between their centers.

Magnetic poles are not fundamental entities, but the results of something much more fundamental, viz. electricity in motion. It was on the basis of an analogy to his law for the force between electric charges that Coulomb set up this last equation; and often analogies are not consistent. While Coulomb was very successful in setting up his analogy, it has led us into difficulties in our thinking as can be shown presently, p.

Coulomb's law for the forces between magnetic poles is, however, water over the dam. It, along with other false conceptions such as magnetic flux, has positively slowed up our advances in the theories of magnetism.

Almost ten years ago Bozorth,[2] in an excellent article, warned physics teachers that modern textbooks of physics were not keeping up with the recent advances in magnetism, and pointed out how some of these defects might be remedied. The present writer believes this lag between general knowledge and actual advancement is in no small measure connected with our false concepts of magnetostatics, that field of knowledge represented by Coulomb's equation for the forces between magnetic poles. These chapters are written for the purpose of seeing how far we can remedy this error in our thinking and set ourselves on the right road to a better understanding of the modern theories concerning magnetism.

The concept of isolated magnetic poles is so firmly entrenched in our thinking and so employed in our definitions of magnetic field intensities and directions that the present author is not one who would throw the whole concept out of the window and start *de novo* with our modern ideas of magnetostatics. Some magneticians would do this, but until our knowledge has grown to a point where we can express all the properties of a plain bar magnet in terms of the magnetic field and the magnetic moment of a spinning electron, we shall do well to hold on to the still useful knowledge of magnetic poles. For instance, a spinning electron has a definite magnetic moment. How can we relate this to the magnetic moment of a bar magnet?

We shall, therefore, continue this chapter, showing how we have set up a system of measurements of magnetic fields in terms of isolated magnetic poles, and then in succeeding chapters try to show how this

[2] Bozorth, R. M., Amer. Jour. Phys., Vol. 10, pp. 73–78, 1942.

may be done in terms of moving electric charges, which are fundamental. Curiously, Ampere did this for us 125 years ago, but for reasons not too clear, we lost sight of Ampere's lucid exposition that all magnetic phenomena could be explained in terms of moving electric charges.

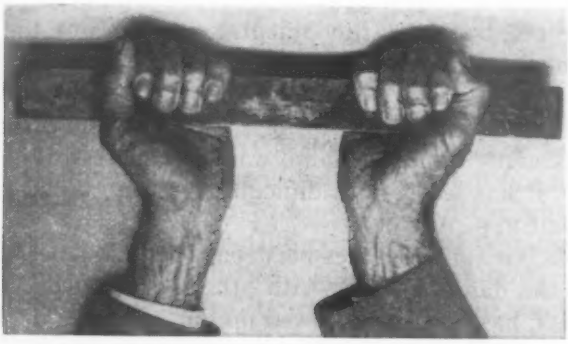

FIG. 8. In holding a magnet in the two hands, there appears to be a *N*-pole in the right hand and a *S*-pole in the left

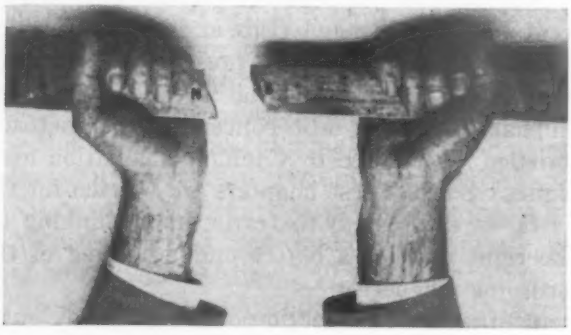

FIG. 9. On breaking the magnet in two, there remains in each hand a dipole

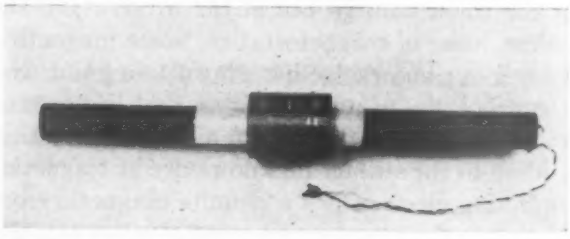

FIG. 10. A solenoid 22 cm long and about 1 cm in diameter

Once more let it be said that Coulomb's equation for the forces between magnetic poles is based on the idea that we are dealing with isolated magnetic poles, just as Coulomb did for electric charges.

Isolated Magnetic Poles Do Not Exist. They always occur in pairs (dipoles). In order to make this point clearer, let us anticipate chapter 2 by using an artificial magnet in place of a natural one. Artificial magnets are more easily obtained than the natural. Suppose one grasps a magnet in his two hands as in Fig. 8. He seems to be holding a N-pole in one hand and a S-pole in the other. When the magnet is broken in two, as in Fig. 9, no longer is there a N-pole in one hand and a S-pole in the other. Each hand holds a dipole. Magnetic poles cannot be separated as electric charges are.

One may approach a condition, experimentally, not far from that of an isolated magnetic pole, by the use of a very long, slim solenoid in which an electric current is flowing. But even here a dipole is formed. A solenoid is a long coil of wire as shown in Fig. 10. The metal clamp about its middle portion is for suspension purposes. When an

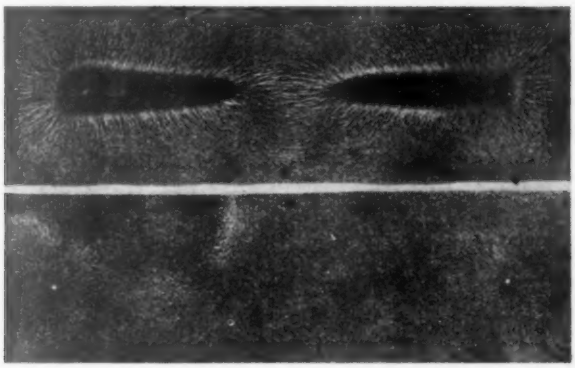

FIG. 11. Positions of the poles in a solenoid when (A) it has an iron core and (B) an air core. In A the iron core is the same length as the solenoid.

electric current flows through the coil it produces a magnetic field much like a long slim piece of magnetite. The coil shown in Fig. 10 is 22 cm long and about 1 cm in diameter. When there is no iron in the core of this coil, the poles produced are very close to the ends of the coil as shown in B, Fig. 11; but when an iron core of equal length is introduced it is difficult to locate the exact positions of the two poles of the resultant magnet as shown in A, Fig. 11. This all goes to show that a long, slim magnet is the best means we have for attaining an approach to an isolated magnetic pole. The effect of one pole on that at the other end is negligibly small, and so Coulomb could write and verify with considerable accuracy that the force between two isolated (assumed) magnetic poles, whether of attraction or of repulsion, could be represented by the formula

$$F = m_1 \times \frac{m_2}{\mu R^2}.$$

Out of this equation then grew the definition of a unit magnetic pole. By taking R equal to unity, the poles m_1 and m_2 would be unity when the force was unity and μ of the same value. It was purely an empirical relationship by which one could define a unit magnetic pole. In the metric system, therefore, a unit magnetic pole would exist when such a pole exerted a force of one dyne on a similar pole at a distance of one centimeter in a vacuum. To this day the question as to whether μ should go in the numerator or in the denominator has never been experimentally confirmed.

Extending the interpretation of this equation and keeping $\mu=1$, we see that $m_2/R^2=H$, the field intensity of the magnetic field of m_2 at a distance of R, where m_1 has been set equal to unity. This comes about because we have defined the magnetic field intensity at any point in a magnetic field as the force in dynes which that magnetic field exerts on a unit magnetic pole placed at the point being considered in the magnetic field.

Furthermore, following the analogy between electric charges and magnetic poles, we go one step farther and define the direction of a magnetic field as the direction in which an isolated positive magnetic pole would move were it free to do so. Thus direction and magnitude of magnetic fields are defined in terms of isolated magnetic poles, but there "ain't no such animal." We start out on a false premise which sooner or later will get us into false reasoning. This is made particularly clear in an article by Tripp[3] on "An Analysis of Electromagnetic Forces."

Summing up the facts given in this chapter we find that a natural magnet, like magnetite, possesses two distinct properties: (a) the power to attract iron particles to it, (b) the power to set its magnetic axis parallel to a magnetic field in which it is placed.

Whenever any body possesses these two properties, as does magnetite, we say it is magnetized, and the same body may be called a magnetized body or a magnet. Our terminology is not always logical. Thus, a body showing the two properties listed above is said to possess magnetism, as though there were a substance which had been injected into it at some time or other to make it magnetic. Later on we shall run into the term magnetic flux, again a misnomer, which arose in the early development of the theory of magnetism in which it was believed that magnetism was a subtle fluid which flowed in a magnetized body.

The two salient properties of natural magnets, just discussed, remained the chief bits of information man possessed about magnetism for about 2200 years, i.e., from 640 B.C. down to the time of Dr. William Gilbert, Physician to Queen Elizabeth.

[3] Tripp, Wm. A., *Electrical Engineering*, October 1945 issue.

One is able by using natural magnets to go a long way in explaining the behavior of magnetized materials. However, it is possible to produce artificial magnets much stronger than the natural ones and in any form one may desire. Hence, it would seem more realistic to deal with artificial magnets because we believe that the conditions which exist in artificial magnets are similar to those found in natural magnets, only to a much larger and more effective degree. The further development of the elementary theory of magnetism will, therefore, be carried out with artificial magnets because the controls for direction and magnitude are so much better.

Before leaving this consideration of natural magnets, some of our readers might find it of great interest to read Dr. William Gilbert's (1544–1603) book, *On the Magnet*, published in 1600 A.D., and now to be had in an excellent translation into English. "This treatise by William Gilbert, of Colchester, Physician of London, on the magnet, was first publisht in the Latin tongue in London in the year of our Lord, M.D.C.; This English translation, which was completed in the year M.C.M., is printed for the Gilbert Club, to the number of two hundred and fifty copies, by Charles Whittingham and Company, at the Chiswick Press, Tooks Court, Chancery Lane, London." The guiding hand in translating this large volume was that of Professor Sylvanus P. Thompson.

In this book Gilbert has brought together much that was in a confused and disorganized state. By the addition of a great deal of new experimental evidence, he has clarified the subject of magnetism as no one else had done up to his time. As one writer has said, "Gilbert was an ingenious experimenter and established most of the commonly known facts about magnets, except those associated with electric currents." Undoubtedly Gilbert was the most distinguished scientist of his age.

Historically it may be interesting to add that Tiberius Cavallo in the 3d edition of his book, *A Treatise on Magnetism*, 1800 A.D., gives in the supplement to that volume, p. 299, a letter by Peter Adsiger, which had been buried in the archives of the University of Leyden, describing the nature of the magnet. As Cavallo says—"The curiosity of this letter, which has never appeared in print, consists in its containing almost all that at present is known on the subject, at least the most remarkable parts of it, mixed however with a good deal of absurdity. The laws of magnetic attraction, and of the communication of that power to iron, the directive property of the natural magnet, as well as that of iron that has been touched by it, and even the declination of the magnetic needle, are clearly and unequivocally mentioned in it." Gilbert wrote his book in 1600 and Adsiger his letter in 1269 A.D., 331 years before Gilbert.

As we turn to succeeding chapters the attempt will be made to get away from the false premise of isolated magnetic poles, and emphasize the concept of electricity in motion as being the most fundamental idea in our modern theories of magnetism.*

* This is the first chapter of a book (to be published later) by one of the leading authorities on the subject. If you want more of the book, write the editor of SCHOOL SCIENCE AND MATHEMATICS.

DOES UNITY DIVIDED BY ZERO EQUAL INFINITY?

CECIL B. READ
University of Wichita, Wichita, Kansas

Many students in mathematics fail to make any distinction between the expression $1/0$, which is not defined, and the limit approached by $1/x$ as the variable x approaches zero as a limit. In fact, it is not unusual to find students who say that since two divided by zero is infinity, and also one divided by zero is infinity, it follows that $2/0+1/0=2\infty$.

In an attempt to impress upon the student that the proper handling of such expressions is a matter of general agreement among mathematicians, and not merely a personal whim of mine, I have offered to grant a considerable amount of extra credit to any student who can find for me in any recent book the unqualified statement that a constant divided by zero is equal to infinity. So far, I have not had to pay off on the offer, but I feel that several students have gained valuable information in their search for such a statement.

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Financing Adult Education in Selected Schools and Community Colleges. By Homer Kempfer and William R. Wood. Office of Education Bulletin 1952, No. 8. 27 pages. For sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. 15 cents.

Tiny grinding wheel is only 1/16 of an inch in diameter and is mounted on a steel shank. Sometimes called an "abrasive point," the wheel can be used for grinding extremely small holes in metal or for polishing precision parts.

THE TEXTBOOK VERSUS SUPPLEMENTAL MATERIAL IN TEACHING BIOLOGY

WAYNE A. STAFFORD
Godwin Heights High School, Grand Rapids, Michigan

THE PROBLEM

There is ample evidence, both direct and tacit, that biology has justified its place in the curriculum of the secondary school. Heiss, Obourn, and Hoffman[1] not only support this viewpoint but also indicate the grade level to which it is ordinarily assigned. They state:

"On the Senior High School level, general biology is well established as a tenth grade course and is usually offered as an elective for each of three years. There is a considerable body of evidence available that seems to indicate that both general science and *biology* are going a long way toward meeting the needs of the young people. Improvement is always possible and no doubt these courses are being improved from year to year."

However, the successful teaching of a course in biology involves the presentation of many and varied experiences to the student. Among such experiences are lectures, field trips, individual laboratory exercises, demonstrations, and the use of the textbook. The use of the textbook, however, has evoked more controversy than any other experience. Most of the arguments for and against textbooks have been well compromised in the following statement from the Forty-Sixth Yearbook[2] of the National Society for the Study of Education.

"In general, what seems likely to prove most satisfactory is to select a basic textbook that provides a good general outline of the course and the primary text materials which all the class may be expected to study and then to supplement this foundational material with a variety of materials from other textbooks, periodicals, and reference works."

However, a search of the literature fails to reveal any studies that either substantiate or negate the above statement. Hence it is the purpose of this study to compare the effectiveness of teaching biology in one class with a textbook, and in a second with supplemental materials only.

METHODS EMPLOYED

During the progress of this study the author was employed in Ravenna High School, Ravenna, Michigan. Hence it was decided to carry out the experiment within the framework of the courses in biology there.

The first task in carrying out the investigation was to select a

[1] Heiss, Elwood D., Obourn, Ellsworth S., and Hoffman, Charles W., *Modern Science Teaching*, The Macmillan Company, New York, p. 17. (Underlining that of author.)

[2] *Science Education In American Schools*, Forty-Sixth Yearbook of the National Society for the Study of Education, Part I, Chicago: Distributed by The University of Chicago Press, 1947, p. 48.

textbook that was in harmony with the major objectives of the teaching of science, namely the understanding of scientific principles, the development of scientific attitudes, and the development of skills in scientific method. The textbook by Curtis *et al.*[3] was chosen because it is designed, according to the authors, to meet the objectives just stated. An examination of the textbook tends to substantiate the view that it does.

The next step was to locate supplemental materials that would cover the same areas as those found in the textbook. A search was made therefore to locate sources of free supplemental materials that would be of value for the purpose intended. Among the various sources located, the following seemed to list or have available such supplemental materials:

1. National Science Teachers' Association
2. General Mills, Incorporated
3. John Hancock Insurance Company
4. Metropolitan Life Insurance Company
5. General Biological Supply House

From these sources were obtained most of the supplemental materials that were needed for the study.

Organization of Supplemental Materials

It was obvious that, if the experiment were to be valid, the supplemental materials would have to provide information on the same topics as found in the textbook, and substantially to the same extent. Further, they would need to be organized into a sequence similar to the units in the textbook. Hence, an outline of the textbook was made.

The outline consisted of the titles of the units and the chapters in the textbook. The supplemental materials were classified and arranged so that they were in the same general topical arrangement as the textbook outline. Then the supplemental materials were compared with the subject matter found under the units and chapters in the books. If one item of the supplemental material covered substantially the same subject matter as one section in the textbook it was retained. If it did not, it was discarded. This process was continued until every area of subject matter in the textbook was matched with a supplemental material that dealt with the same topic, or topics.

Two similar sets of published materials were then available, (1) a textbook, and (2) supplemental materials covering the same areas and arranged in the same order, as the topics in the textbooks.

The following is an example of the process by which the textbook

[3] Curtis, Francis D., Caldwell, Otis W., and Sherman, Nina H., *Everyday Biology*, Boston: Ginn and Company, 1947, pp. 3–608.

and supplemental materials were matched with one another:

Chapter in Textbook	Titles of Supplemental Material
Chapter XIV: Conservation of Natural Resources and Wildlife	*Conservation*[a]
	You & Forest Fires[b]
	Ten Years of Soil Conservation[c]
	Know Your Watersheds[d]
	Soil Conservation[e]
	Cereals[f]

[a] *Conservation*, Washington 6, D. C., American Forests Products, Inc., 1319 18th Street, N. W.
[b] *You & Forest Fires*, Washington 6, D. C., American Forests Products Inc., 1319 18th Street, N. W.
[c] *Ten Years of Soil Conservation*, Muskegon, Michigan, Muskegon County Conservation Department.
[d] *Know Your Watersheds*, Washington 6, D. C., American Forests Products Inc., 1319 18th Street N. W.
[e] *Soil Conservation*, Moline, Illinois, John Deere Inc.
[f] *Cereals*, Minneapolis, Minnesota, General Mills, Inc.

Equating the Groups of Students

In the Ravenna High School for the school year 1949–50, forty (40) students enrolled for the course in biology. The students were distributed in two classes of twenty each. After a few days the classes were reorganized so that they were fairly well equated on the basis of age, sex, and mental ability.

The test used to measure mental ability was the *New California Short-Form Test of Mental Maturity Advanced '47 S-Form.*[4]

However, the plan to teach these groups thus equated underwent some modification. A shift in the schedule of a home economics class necessitated the movement of some of the pupils from one class to another. Hence, one of the biology classes had fourteen (14) members and the other twenty-six (26).

The pupils in these rearranged groups remained in their respective class then throughout the year. No further effort was made to equate the two groups. But, there was no evidence that either group was distinctly superior to the other.

Table I that follows compares the two groups on the bases on which they were equated.

Table I. Equating of Groups in this Study

Group	Sex		Age		
	M	F	15	16	17
I	8	6	8	4	2
II	14	12	20	2	4

The Rotational Technique

In order to compensate for any differences that might exist be-

[4] Sullivan, Elizabeth T., Clark, Willis W., and Tiegs, Ernest W., *New California Short-Form Test of Mental Maturity Advanced '47 S-Form*. 1947 Edition.

tween the two groups, it was decided to carry out the experiment by using the rotational technique in teaching the course in biology. Good, Barr, and Scates[5] describe the rotational technique as follows:

"The rotation method involves the reversal of the groups at intervals, in terms of the procedures followed. This method is frequently used when parallel groups are not available or there is doubt concerning the equivalence of the groups, due to such factors as initiative, industry, or study habits which are very difficult if not impossible to control. The groups may be reversed as often as desired by the investigator."

The author's use of the rotational technique consisted of first teaching the biology class of fourteen (14) pupils (designated hereafter as "A" group) the first semester of work from the supplemental material. The second semester group A received their biology information from the textbook. The biology class of twenty-six (26) pupils (designated hereafter as "B" group) used the textbook the first semester and then the second semester used the supplemental material. Table II that follows depicts the procedure in its entirety.

TABLE II. ROTATIONAL GROUP TECHNIQUE

Teaching Method I (Supplemental Material)	Teaching Method II (Textbook)
First Semester	
Pretest	Pretest
Group A	Group B
Midtest	Midtest
Second Semester	
Group B	Group A
Final Test	Final Test

SELECTION OF A BIOLOGY TEST

The next step was to select a test in biology that would be suitable for use in this study. A search of the literature brought to light such a test. The test was the 1947 Minnesota State Board Examination for Biology. It was selected since it was the only test for which extensive data dealing with reliability and validity were available. The test, according to Anderson[6] included items that would help to produce a realistic program of instruction including (1) continuous measurement and evaluation, (2) factors contributing to achievement of science objectives, and (3) "straight-forward method."

[5] Good, Carter V., Barr, A. S., and Scates, Douglas E., *The Methodology of Educational Research*, New York: D. Appleton-Century Company, Inc., 1941, p. 495.

[6] Anderson, Kenneth. E, "A Frontal Attack on the Basic Problem in Evaluation: The Achievement of the Objectives of Instruction in Specific Areas," *Journal of Experimental Education*, Vol. XVIII, March 1950, pp. 163–174.

Analysis of Results

Table III contains the average amounts of improvement made by both groups on the test during both semesters.

Table III. Differences in Growth in Achievement

Group	Average Amount of Growth First Semester	Average Amount of Growth Second Semester	Differences in Growth Between Groups A and B
A	12.35	12.5	1.31
B	11.04	11.54	.96

In order to determine whether the differences indicated in this study were significant, it was decided to use the "*t*" test for significance cited by Guilford.[7] This test was especially suitable for use in this study because of the small size of the samples. Table IV contains these computations.

Table IV. Differences of Growth Between Groups A and B

Period	Mean Difference	SD Difference	"t"	Interpretation
First Semester	1.31	.14	.343	No Significance
Second Semester	.96	.38	.225	No Significance

Conclusions

In so far as the techniques used in this study may be valid, the following conclusions seem justified:

1. Great amounts of supplemental material of value for use in courses in high-school biology were found to be available.
2. At the expense of a great deal of time and energy this supplemental material can be organized into a form that might be used to replace a textbook in so far as subject matter is concerned.
3. There was evidence that every student grew in biology achievement during *both* semesters under both systems.
4. The first semester Group A (Textbook) grew more in achievement than Group B (Supplemental). The difference in growth amounted to an average of *1.70* points per pupil.
5. The second semester Group A (Supplemental) grew more in achievement than Group B (Textbook). The differences in growth amounted to an average of *1.31* points per pupil.
6. The differences in growth in achievement in biology of Group

[7] Guilford, J. P., *Psychometric Methods*, New York: McGraw-Hill Book Company, 1936, p. 61–2.

A over Group B were not significant either semester. (See Table IV.)

7. The differences in achievement in biology during both semesters was apparently influenced more by the personnel in Group A than by the type of reference material used.

8. The evidence from this study, although limited in scope substantiates the statement in the 46th Yearbook of the National Society for the Study of Education with respect to the use of textbook. This statement reads:

> "The desirable procedure, is not to get rid of the textbook (because any textbook is likely to provide better materials than the average teacher can improvise or assemble in the time and with the facilities available) but to avoid restricting the study to the contents of a single textbook, and instead, to supplement it as abundantly as may be necessary."

Recommendations

In view of the results of the study, the following recommendations and suggestions seem reasonable:

1. That this study be repeated in a number of other schools in order to negate or substantiate its findings.

2. That the amount of work involved in preparing and organizing supplemental material does not seem to justify the replacement of the textbook, if the findings of this study are valid.

3. Since most teachers will not or cannot devote the interest and effort to using supplemental materials in the same manner as in this study, the replacement of the textbook in the manner indicated is not likely to be feasible.

4. That the best use of supplemental material is to supplement, but not to replace the textbook.

THE SCHOOL LUNCH

School lunch programs, from their small beginnings early in the century, are becoming increasingly important to the education, health, and well-being of the youth of America.

This publication contains, in considerable detail, information relative to the types of State laws which enable the State departments of education to participate in the National School Lunch Program and the varying forms of school lunch organization which exist within their departments.

The school lunch program has not yet reached the stage of development where it is available to all children and youth who need it. It is hoped that this new publication will be of considerable help to all State departments of education.

State Provisions for School Lunch Programs—Laws and Personnel. By Myrtis Keels Jeffers. Office of Education Bulletin 1952, No. 4. 40 pages. For sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. 20 cents.

MOTIVATING THE STUDY OF SOLID GEOMETRY THROUGH THE USE OF MINERAL CRYSTALS

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"Nature geometrizeth and observeth order in all things."
Sir Thomas Brown

Part I

Solid geometry is concerned with the study of relationships which exist among bodies and parts of bodies which we can see with our eyes or hold in our hands, spatial relationships among points, lines, surfaces, and volumes. Such things are interesting in an abstract sense and for their own sake to certain types of people, but to others, any abstract consideration seems worthless unless it is "brought down to earth." It can not be denied that mineral crystals provide an exceptionally literal means of bringing solid geometry down to earth. They furnish very convincing evidence of at least one practical application of the subject.

The teacher who is interested in using mineral crystals in his classroom must know the answer to three questions: I. What should the teacher of solid geometry know about mineral crystals if he is to use them for purposes of motivation? II. How may this knowledge be used in the classroom? III. What materials are necessary, and where may these materials be obtained?

The discussion which follows is designed to answer the first of these. A second article, which will discuss the other two questions, will be published in a later issue. The second article will include a bibliography.

A. *What Should the Teacher of Solid Geometry Know about Mineral Crystals If He Is to Use Them for Purposes of Motivation?*

The solid part of our earth is known as the lithosphere, which literally translated means "ball of rock." More correctly, we should say "ball of rocks," for the materials which form the lithosphere are of many different kinds, with different origins. Even one sort of rock, granite, for example, may consist of several things. Some grains in a piece of granite are dark, some are light; some have satiny surfaces, while others resemble bits of glass; some are harder than others; they show differences in color. These substances are minerals with such names as mica, quartz, feldspar, and hornblende.

The mineralogist's definition of a mineral differs somewhat from

the layman's concept of the term. We shall accept the mineralogist's definition: A mineral is a naturally occurring, homogeneous, inorganic substance. This terse statement requires a little thought about the three descriptive adjectives, "naturally occurring, homogeneous, inorganic." Window glass is not naturally occurring, granite is not homogeneous, coal is not an inorganic substance, so all these are not minerals in the technical sense, although they belong to the so-called "mineral world" as distinguished from the "animal and vegetable worlds."

According to common belief, minerals, as well as all other substances, are made up of extremely small particles called molecules which in any homogeneous substance are all alike in composition, size, and weight, but are unlike in these particulars in different substances. Molecules are separated from each other to some extent even in the hardest and most dense of materials. There are universal forces of mutual attraction which tend to hold each molecule in position with respect to adjacent molecules, and against which are opposed forces which would produce motion. The relative strength of these two kinds of forces determines whether a substance is a gas, a liquid, or a solid.

When the constituent molecules of a substance are arranged according to no definite pattern, the substance is said to be amorphous or to possess an amorphous structure. Glass is an excellent illustration of an amorphous material.

When the constituent molecules of a substance are arranged in some definite pattern, the substance is said to be crystalline or to possess crystalline structure. A majority of minerals, as well as many artificial substances, have crystalline structure.

Crystalline substances may resemble amorphous ones very closely, at least superficially, but they can usually be recognized by the presence of cleavage, or distinctive optical, electrical, thermal, or other physical properties which prove that in crystalline materials there are certain directions along which forces or agents act with quite different effects from those produced in other directions.

When a crystalline substance, in passing into a solid state from that of either a liquid or a gas, is free to form without interference, it assumes a distinctive geometrical form called a crystal. This crystal is bounded wholly or partially by natural plane surfaces called faces. *The crystal is the outward expression of the orderly internal arrangement of the molecules.* For this reason, crystal form is the most important of all the physical properties of a given type of mineral and the one that most generally characterizes it. Most minerals, even though no crystals are visible, have the orderly internal structure of a crystal.

From what has been said, it must be evident that a crystal always

has crystalline structure, but that crystalline substances do not by any means always occur in crystals. Crystals are the exception rather than the rule, and develop only when conditions are favorable.

We are interested, at present, only in crystals, and specifically in the geometrical characteristics of crystals, their size, their shape, and the relative positions of their faces and vertices.

Crystals vary in size from microscopic to a size that would not fit into an ordinary room, the largest known thus far being crystals of spodumene more than forty feet long that have been found in the Black Hills of South Dakota.

It is convenient to study the shape of crystals with reference to centers of symmetry. These centers may be points, lines, or planes. When the center of symmetry is a line, this line may be called an axis of symmetry. It is almost an emotional experience when we discover that all crystals fall naturally into six groups defined by the length and angular relationships of their axes. (While the crystal axes and the axes of symmetry are not always coincident, no distinction will be made here.) These six groups are known as the crystal systems, and will now be described separately:

I. The Isometric or Cubic System: This system has three mutually perpendicular axes of equal length (Figure 1). The arrangement of faces about the six ends of the axes are always the same; that is, any way you turn the crystal, it looks the same to you. Perfect crystals take the shape of a cube (galena, halite or common salt, fluorite), an octahedron (magnetite, franklinite), a dodecahedron (garnet), a trapezohedron (other varieties of garnet), or a pyritohedron with twelve faces each a pentagon, actually a pentagonal dodecahedron (pyrite). The mineralogist's octahedron and tetrahedron must be what the geometrician calls "regular." Two or more forms of the same system may occur in a single crystal.

II. The Tetragonal System: This system has three mutually perpendicular axes, two of which are of equal length, and the third of which is either longer or shorter than the other two (Figure 2). The arrangement of faces is the same about the ends of the equal axes, but different around the other one. Tetragonal crystals may take the form of tetragonal prism, the square prism of geometry (zircon), a tetragonal dipyramid, eight faces, each isosceles triangles (zircon), or a disphenoid, four faces, each isosceles triangles (chalcopyrite).

III. The Hexagonal System: This system has three horizontal axes of equal length making angles of 60° with each other and a fourth axis perpendicular to all of these and shorter or longer than the horizontal axes. The hexagonal system differs from all the others in that it has four crystallographic axes of reference rather than three

(Figure 3). Crystals of the hexagonal system may take the shape of a dipyramid (usually combined with other hexagonal forms), a hexagonal prism (quartz), a rhombohedron which is a six-sided solid

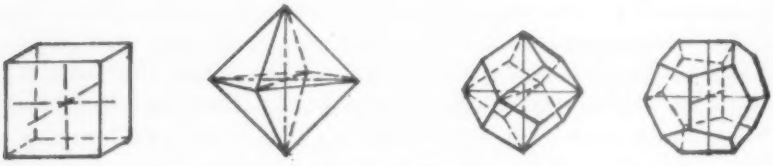

FIG. 1. Isometric forms: cube, octohedron, dodecahedron, pyritohedron

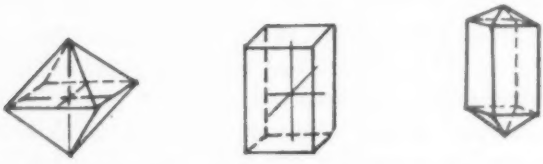

FIG. 2. Tetragonal forms: dipyramid, prism, zircon crystal

FIG. 3. Hexagonal forms: prism, dipyramid, calcite crystal

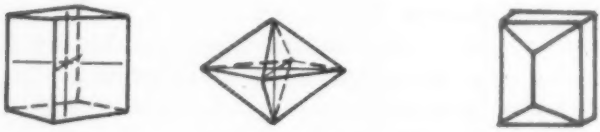

FIG. 4. Orthorhombic forms: prism, dipyramid, staurolite

FIG. 5. Monoclinic forms: prism, gypsum

FIG. 6. Triclinic crystal

each face of which is a rhomb (hematite, tourmaline), or a scalenohedron which is a twelve-sided solid looking somewhat like a double six-sided pyramid except that the faces are scalene triangles and the edge is zigzag instead of horizontal as in the dipyramid. Calcite is one mineral which crystallizes in the hexagonal scalenohedron class, often combined with other hexagonal forms. It frequently happens that two or more forms of the hexagonal system occur together; quartz, for example, commonly crystallizes in a hexagonal prism topped by six pyramidal faces (two rhombohedrons) each having the shape of an acute isosceles triangle. Emerald, ruby, and sapphire also belong to the hexagonal system.

IV. The Orthorhombic System: The orthorhombic system has three unequal axes at right angles to each other (Figure 4). There are two common forms of this system: the prism made up of four similar vertical faces in which a cross section would be a rhomb, not a square as in the prism of the tetragonal system; and the dipyramid which differs from the tetragonal dipyramid in the same manner. Sulfur, staurolite (fairy stone), and topaz are some of the minerals which crystallize in the orthorhombic system.

V. The Monoclinic System: In the monoclinic system, there are three axes of unequal length; two of them are at right angles, but the third is inclined to the plane of the other two. The system is named monoclinic because of this one inclined axis (Figure 5). The forms of the monoclinic system are similar to those of the orthorhombic, but the lower symmetry brought about by the inclination of an axis introduces some half-forms. The only form of this system which would be apparent to the novice is the monoclinic prism, made up of four similar vertical faces, the intersections of which do not form right angles. Spodumene, and most of the micas, amphiboles, and pyroxenes are monoclinic.

The prismatic forms of systems II, III, IV, and V are open forms, and when these are closed by planes, these planes are called *basal pinacoids*.

VI. The Triclinic System: In the triclinic system, the faces are referred to three unequal axes, all oblique to each other (Figure 6). (The reader surely has suspected this, since it is the only remaining possible variation of our original three axes.) All forms of the triclinic system have only two faces on opposite sides of the crystal. Only a few common minerals occur in this system, a fortunate circumstance for the amateur mineralogist, because the system is extremely complex. Rhodenite and moonstone are two of the minerals which crystallize in the triclinic system.

In all of the six systems, an axis may terminate in a vertex, the midpoint of an edge, or the center of a face of the crystals.

It has been stated that the orderly internal arrangement of atoms of a substance is reflected by the crystal; this same phenomenon is also revealed by the *cleavage*. Cleavage may be described as the tendency, which many minerals possess, to split or separate readily along definite planes. A cleavage marks the direction in which forces binding the atoms together are relatively weak. Thus, galena is said to have cubic cleavage because it separates readily in a direction parallel to each pair of parallel cube faces. In other words, when fractured, galena breaks into a multitude of little cubes. Halite, or common salt, also has perfect cubic cleavage. Fluorite has octahedral cleavage; from a single crystal we may with care break out a perfect octahedron. This cleavage octahedron is somewhat difficult for the amateur to distinguish from an octahedral crystal of fluorite. (Fluorite occasionally crystallizes as an octahedron), but on the cleavage form, the faces are uneven and splintery when viewed under a magnifying glass, not uniform like the normal faces of a crystal. The diamond also possesses octahedral cleavage. Again, from a piece of sphalerite, a dodecahedron may be broken out because of its dodecahedral cleavage. Further, a piece of calcite breaks readily into a number of rhombohedrons (parallelopipeds), all of the same angle, and hence it is said to have rhombohedral cleavage. In the interest of intellectual honesty, the teacher should be careful not to display a cleavage rhombohedron of calcite as a calcite crystal. In the same manner, we find that amphibole has prismatic cleavage; mica has highly perfect basal cleavage, or cleavage parallel to the basal pinacoid, yielding extremely thin sheets; topaz also has basal cleavage. Feldspar shows two cleavages, both nearly perfect but one a little more so than the other, and these make angles of about 90° with each other. All these are examples of perfect cleavage, the only kind which would be of value to the teacher of solid geometry. It is helpful to remember that, even if a crystal does not show broken surfaces, the cleavage is often indicated by lines on the faces of the crystal which may be seen to indicate cleavage planes, or by a fine pearly luster on the face of the crystal to which cleavage is parallel. This pearly luster is due to the presence of cleavage rifts, though the crystal has not actually broken, just as a pile of thin glass sheets shows a pearly luster because of the diverse reflections and refractions of light. Amorphous substances do not possess cleavage, and in many minerals cleavage is imperfect or obtained with difficulty.

In addition, the teacher should know enough about chemistry to tell the content of a given mineral after looking up its chemical formula. She needs to have some knowledge about the structure of matter, the definitions of a mineral and of a crystal, the size of crystals, the six crystal systems, cleavage, and a little chemistry.

MODERN MARKS WITH MEANING

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"What an unfair grade! I didn't deserve that!" How often have you heard or felt that yourself? Most marking systems have serious defects and few measure more than the relative standing of the class. A mark has little meaning from class to class or school to school.

For years I have been dissatisfied with my marking systems. Each year when my students were given an opportunity to criticize me and my teaching they invariably fell upon the current marking system in a fury. As the system evolved and it developed less criticism, I discovered that it was becoming more of a segment of real life as we observed it about us. In its present state it works very well and it measures achievement rather than relative standing.

This system has been in operation in substantially the present form for two years. It is used to grade and evaluate boys and girls from age fifteen through twenty in high school biology. The classes vary from twenty-five to thirty-five in size. The goals of the course are consistent with the seven cardinal principles of education and the goals of science education as outlined in the forty-sixth yearbook of the National Society for the Study of Education. The course is a unit-type making use of extensive sensory aids and giving every opportunity for individuals who wish to do so to develop individual projects large or small on a great variety of activities. Much use is made of the many great skills possessed by young people of this age to assist each other and the teacher in the operation and development of each unit of the course to its greatest practical potential value. A large quantity and type of equipment is available to present demonstrations or perform experiments. Reference books are available in large number and modern textbooks are used. For some years the school has been fortunate to have a liberal and progressive headmaster. All these conditions provide a challenge to the method of marking for here are the conditions necessary for flexibility, individualization, quality and intellectual challenge for all students. The conventional marking systems such as relative rank fails to recognize the achievement that is possible under such conditions. Therefore the present system evolved which does meet the challenge.

The basic assumption is that work must be done. Work to live, to achieve, to succeed, to survive. All men must work. The minimum work necessary to survive in the course is the core material. It consists of the problems of the units. If at the end of each term all the core material has been done and each unit problem checked into the

record with a check or a letter T then the student has earned the minimum grade of D minus. If a student has learned the value of punctuality and submitted all his units for inspection when due and thus has received all check marks with no more than one letter T his minimum grade becomes C minus. Periodically unit examinations or quizzes are given. If a student can pass them all and has already earned a C minus or a D plus then his minimum grade becomes B

A GRADING SYSTEM FOR A UNIT TYPE COURSE

Pupils Names	H.R.	Class	Core Materials										Quality Testing				
													None				
Jones, Robert	1	s	√	√	T	√	T	T	√								
Smith, Mary	3	s	√	√	√	T	√	√	T	T	√	T	F	P	P	F	
Brown, John	6	s	√	T	√	√	√	T	√	√	T	√	P	F	F	F	
Thompson, Elizabeth	14	s	√	√	T	√	√	T	√	√	√	√	P	P	F	F	
Albini, June	14	s	√	√	√	√	√	√	T	√	√	√	P	F	F	F	
Jenkins, Harold	19	s	√	√	√	√	√	√	√	√	√	√	P	P	F	F	
Petersen, Peter	21	J	√	√	√	T	√	√	√	√	√	√	P	P	F	F	
Earlich, Paul	21	J	√	√	√	√	√	√	√	√	√	√	P	P	P	P	
Russeau, Jean	26	J	√	√	√	√	√	T	√	√	√	√	P	F	P	P	
Speyer, Andre	30	S	√	√	√	√	√	√	√	√	√	√	P	P	F	P	
Foley, Tom	31	S	√	√	T	√	√	√	√	√	√	√	P	P	F	P	
Carpenter, William	36	S	√	√	√	√	√	√	√	T	√	√	P	F	P	P	
Newton, Isaac	38	S	√	√	√	√	√	√	√	√	√	√	P	P	P	P	

D — if all completed
C — if all completed on time
√ = completed on time
T = completed but late one T allowed

B — if all passed but one
P = passed test
F = failed test one F allowed

R.D.M. 1951

Date: 10/ 1/51	Unit # 1 Exploratory Reading
" 10/ 7/51	" # 1 Reports
" 10/14/51	" # 3 Discussions
" 10/21/51	" # 4 Problems
" 10/27/51	" # 5 Problem Solving
" 11/ 3/51	# 6 Testing Results
" 11/10/51	" # 7 Conclusion
" 11/17/51	" # 8 Bibliography
" 11/24/51	" # 9 Writing Reports
" 12/ 1/51	" #10 Presenting Reports
Date: 10/19/51	Test # 1 Reading
" 11/ 1/51	" # 2 Analysis
" 11/ 8/51	" # 3 Summarizing
" 11/28/51	" # 4 Writing

minus. Certain students are motivated to do optional related work, usually individual projects. If these are well done and the student has already qualified for a grade of B minus he now is qualified for a minimum grade of A minus. In all instances of letter grades earned, a minus grade was stipulated. This allows the teacher to award a straight or even a plus grade in payment for the little extras that students do to enrich their own study, the course for others, and the

USING THE CONTRACT, 5 GRADE METHOD

Optional Related Activities	Special Considerations	Grade
NONE	CHRONIC SICKNESS	F
NONE		D−
NONE		D
NONE	NEWSPAPER CLIPPINGS	D+
NONE		C−
NONE	MAGAZINE ARTICLES	C
WROTE A TERM PAPER	NEWSPAPER CLIPPINGS & REF. BOOK	C+
NONE		B−
NONE	CONTRIBUTED 4 REFERENCE BOOKS	B
NONE	CHAIRMAN OF CLASS COMMITTEE	B+
BUILT A MODEL		A−
TERM PAPER, READ IT TO THE CLASS	BROUGHT IN A SPEAKER	A
COMPLETED A RESEARCH PROJECT, DEMONSTRATED IT	GAVE PROJECT AND MODEL TO CLASS	A+
A− if a project is perfected. No credit for an A− is allowed unless a B− is first earned.	These can raise a minus grade to a straight or a plus grade.	

environment of the class as a whole. These should be recognized and paid for or such behavior may cease.

It will be observed that the marking system recognizes and gives credit for achievement in the development of such qualities as we in our democracy have learned to highly prize that make for good living. These qualities are as follows: self support as done in the core materials, desirable personality traits, as done in the punctuality credit, quality achievement as done in passing the examinations, individual accomplishment as done in the optional projects, social generosity as done in the special enrichment considerations. Last but not least, let it be remembered that a failing grade of F minus may be earned by he who fails to demonstrate his ability to self support by failure to accomplish all the core material. It is believed that this system called, "Modern Marks with Meaning" is consistent with life.

"Modern Marks with Meaning" presents a type of marking system for public schools or colleges that may be the solution to a serious problem in grading students. It offers a set of letter grades that may be briefly characterized as follows:

F—Incomplete or unacceptable work.
D—Minimum core material completed.
C—Minimum core material completed punctually and earning a punctuality premium.
B—Earning a C— or D+ and passing the tests.
A—Earning a B— and perfecting a project. Straight or plus grades may be earned by contributions to the class or course betterment beyond the regular or core requirements or projects.

The author will be glad to further clarify this method by personal correspondence.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Missouri

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the Department desires to serve his readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.
2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.
3. In general when several solutions are correct, the one submitted in the best form will be used.

Late Solutions

2309, 10. *C. W. Trigg, Los Angeles City College.*

2294, 5. *Hugo Brandt, Chicago.*

2311. *Proposed by J. C. Williams, Chicago.*

A candy dish contains 25 vanilla creams, 10 maple creams, and 10 raspberry creams. What is the least number one must take out of the bowl to be sure of having

a) two with same flavor
b) two with different flavors
c) three with different flavors
d) three with same flavor.

Solution by V. C. Bailey, Evansville College, Evansville, Ind.

a) If the first three drawn are of different flavors, then the fourth one would guarantee two with the same flavor.
b) The first 25 may be of one flavor. The 26th draw would guarantee two with different flavors.
c) Thirty-five creams may be drawn and yet have only two flavors. The 36th draw would then guarantee three with different flavors.
d) If the first six drawn are two of each flavor, then the 7th draw would guarantee three of one flavor.

Solutions were also offered by: Leon Bankoff, Los Angeles; Hugo Brandt, Chicago; C. W. Trigg, Los Angeles City College; Julian H. Braun, Washington; Eugene Roberts, San Francisco; Dewey C. Duncan, Los Angeles; W. R. Smith, Suttons Bay, Mich.; Charles McCracken, Jr. Cincinnati; Walter A. Stahl, Cleveland.

2312. *Proposed by Hugo Brandt, Chicago.*

For the ellipse, $x^2+7y^2-7=0$, find points on line $x=y$ such that of two of the tangents to the ellipse, one is twice as long as the other.

Solution by Williard Glazer, Troy, N. Y.

Let $P'(x', y')$ be the point of tangency. Let (α, α) be the required point. Then

$$x'\alpha+7y'd=7 \tag{1}$$

is the equation of the tangent.

$$x'^2+7y'^2=7. \tag{2}$$

Solving for x' and y', one obtains

$$x'=\frac{7-7p}{8\alpha}, \qquad x''=\frac{7+p}{8\alpha}$$

$$y'=\frac{7+p}{8\alpha}, \qquad y''=\frac{7-p}{8\alpha} \quad \text{where} \quad p=\sqrt{8\alpha^2-7}.$$

The equation $t_1=2t_2$, with t_2 and t_1 the tangent lengths, becomes

(3) $$(x'-\alpha)^2+(y'-\alpha)^2=4[(x''-\alpha)^2+(y''-\alpha)^2].$$

By substitution of values of x', y', x'', y'' and simplifying, one obtains

(4) $$p^2(p-5)^2=0.$$

Hence $p=\sqrt{8\alpha^2-7}=5$ and 0.

In solving for α (4) becomes $\alpha=2$, $\sqrt{14}/4$.

Now $(\sqrt{14}/4, \sqrt{14}/4)$ is on the ellipse and is no solution. The only solutions are (2, 2) and (−2, −2).

Solutions were also offered by: Dewey C. Duncan, Los Angeles; Walter R. Warne, Syracuse, N.Y.; Ira Conley, Macon, Ga.; A. R. Haynes, Tacoma, Wash.; Frances Kinne, Ventura, Calif.; Margaret Porter, Salt Lake City; Frances Moore, Washington, D. C.; and by the Proposer.

2313. *Proposed by Cecil B. Read, Wichita, Kansas.*

If $x+y=4$, with all values of x between 0 and 2 equally probable, show that the probability that xy exceeds 3 is $\frac{1}{2}$.

Solution by V. C. Bailey, Evansville College, Evansville, Ind.

Let $P=xy$, then $P=x(4-x)$. Either from the graph or from the first derivative it can be shown that P has a maximum value of 4 when $x=2$. From a similar study it can be shown that from $x=0$ to $x=1$, xy is less than 3; from $x=1$ to $x=2$, xy is greater than 3. Therefore, in the interval from $x=0$ to $x=2$, one-half the values of xy are greater than three.

Solutions were also offered by: C. W. Trigg, Los Angeles City College; Leon Bankoff, Los Angeles; Julian H. Braun, Washington; Dewey C. Duncan, Los Angeles; Charles McCracken, Jr. Cincinnati; W. R. Smith, Suttons Bay, Mich.; William Giddings, Savannah, N.Y.; Lillian R. Wiley, Macon, Ga.; and the Proposer.

2314. *Proposed by Wm. Giddings, Savannah, N. Y.*

In right triangle ABC, c being the hypothenuse, r radius of incircle, if $a-b=1$, $r=1$ and altitude on AB is 12/5, find the sides of the triangle.

Solution by Leon Bankoff, Los Angeles, Calif.

The point of contact with the incircle divides the hypothenuse, c, in segments equal to $(a-1)$ and $(b-1)$. Then the semi-perimeter, S, is equal to $(a-1)+(b-1)+1$. Since $a-1=b$, we have $s=2b$, and the area, $rs=2b$.

But area $=ab/2=b(b+1)/2$.

Hence $2b=b(b+1)/2$.

Whereupon $b=3$, $a=4$, and $c=5$.

Since the area of this triangle is 6, it follows that the altitude on c is 12/5; but in the statement of the problem this condition is redundant. As demonstrated, the unique solution can be found without this additional data.

Solutions were also offered by: V. Subramanian, Pudakkottai, S. India; C. W. Trigg, Los Angeles City College; Emma Cox, Ridgeway, Mich.; Suessa Blaine, Washington; David Rappaport, Chicago; V. C. Bailey, Evansville, Ind.; Julian H. Braun, Washington; Rogers J. Newman, Jackson, Miss.; Richard H. Bates, Milford, N. Y.; Dorothy Hughitt, Auburn, Me.; David Netboy, San Anselmo, Calif.; Margaret F. Willerding, St. Louis; Maude T. Hanson, Brown Valley, Minn.

2315. *Proposed by Ethel Dildine, Yale, N. Y.*

Solve:

$$x^2+y^2=13$$
$$x^2y+xy^2=30$$

Solution by V. C. Bailey, Evansville, Ind.

(1) $x^2+y^2=13$, (2) $x^2y+xy^2=30$.

From (2)

(3) $x+y=\dfrac{30}{xy}$ or (4) $(x+y)^2=\dfrac{900}{x^2y^2}$.

From (1) and (4)

(5) $2xy=\dfrac{900}{x^2y^2}-13$ or (6) $2x^3y^3+13x^2y^2-900=0$.

Equation (6) is a cubic in (xy) for which there is one real value. That is, $xy=6$. From (3) $x+y=5$. These two equations yield two real solutions.

$$x=2, 3$$
$$y=3, 2.$$

Solutions were also offered by: Hattie Estey, Flint, N. Y.; Ophelia Warne, McDuffietown, N. Y.; Lilliam Rider, Milledgeville, Ga.; Lester Bolander, New York City; Newton Kingrey, Sheridan, Wyo.; Nina Van Nostrand, Flint, N. Y.; Ethel Dildine, Yale, N. Y.; Stewart Adair, Cortland, N. Y.; Julian H. Braun, Washington; C. W. Trigg, Los Angeles City College; Hugo Brandt, Chicago; Dewey C. Duncan, Los Angeles.

2316. *Proposed by Norman Anning, University of Michigan.*

Two points A and B are distinct. If C is mid-point of AB, D of BC, E of CD, F of DE, etc., show that the successive points approach a definite limit-point. If L is the name of this limit-point, find ratio of AL to LB.

Solution by Julian H. Braun, Washington, D.C.

Let AB be set on a linear coördinate system with A at 0 and B at 1. Then let

$$C=p_1=\tfrac{1}{2},$$
$$D=p_2=\tfrac{3}{4},$$
$$E=p_3=\tfrac{5}{8},$$
$$F=p_4=\tfrac{11}{16},$$

and, in general,

$$p_n=\tfrac{2}{3}+\tfrac{1}{3}(-\tfrac{1}{2})^n$$

whence

$$L=\lim_{n\to\infty} p_n=\tfrac{2}{3}.$$

Therefore

$$AL/LB=\frac{\frac{2}{3}}{1-\frac{2}{3}}=2.$$

Solutions were also offered by: C. W. Trigg, Los Angeles City College; Leon Bankoff, Los Angeles; Richard H. Bates, Milford, N. Y.; Hugo Brandt, Chicago.

PROBLEMS FOR SOLUTION

2329. *Proposed by V. C. Bailey, Evansville, Ind.*

Show that the inradius of the triangle EFG, where E, F, G, are feet of the altitudes of triangle ABC, is given by formula: $r=2R\cos A\cos B\cos C$, with R the radius of the circumcircle.

2330. *Proposed by C. W. Trigg, Los Angeles City College.*

If the center of two intersecting circles with radii R and r are at a distance d apart, then show that the length of the common chord is

$$\sqrt{(R+r+d)(R-r+d)(R+r-d)(r-R+d)}/d.$$

2331. *Proposed by Zora Bailey, Sayre, Pa.*

Solve:

$$x^4y^3+2x^3y+x^3+2xy^3=x^3y^4+y^3+x^3y^2$$
$$x^2y+xy^2+x=2xy+y.$$

2332. *Proposed by Richard H. Bates, Milford, N. Y.*

A group of 7 boys had some marbles. In an attempt to divide them equally there were 2 left over. Three more boys joined the group and when the division was again made, a remainder of 9 was discovered. Now another boy joined the group and this time 3 remained after an equal distribution was made. How many marbles did the boys have?

2333. *Proposed by John Satterly, University of Toronto,*

In a triangle ABC, if a point B_1 is selected on side a, such that $BB_1=a/n$, then AB_1 is called a nedian of the triangle. From each vertex there are three such points extending in same directions around the triangle, and also three points extending in the opposite direction. Hence there are two sets of three nedians each. The nedians of each set form a triangle called a nedian triangle. One triangle may be called the forward triangle, and the other the backward triangle.

Problem—The sum of the squares of the nedians of a set in triangle ABC equals $(n^2-n+1/n^2)x(a^2+b^2+c^2)$.

2334. *Proposed by John Satterly, University of Toronto.*

The area of a nedian triangle is $(n-2)^2/n^2-n+1$ times area of the triangle. All nedian triangles have the same centroid as that of the given triangle.

BOOKS AND PAMPHLETS RECEIVED

PRACTICAL MATHEMATICS, Fourth Edition, by Claude Irwin Palmer, *Late Professor of Mathematics and Dean of Students, Armour Institute of Technology*, and Samuel Fletcher Bibb, *Associate Professor of Mathematics, Illinois Institute of Technology*. Cloth. Pages xii+769. 13.5×20.5 cm. 1952. McGraw-Hill Book Company Inc., 330 W. 42nd Street, New York 36, N. Y. Price $4.50.

THE EVOLUTION OF CHEMISTRY, by Eduard Farber, Ph.D., *Chief Chemist of the Timber Engineering Company, Washington, D. C.* Cloth. Pages ix+349. 14.5×23 cm. 1952. The Ronald Press Company, 15 E. 26th Street, New York 10, N. Y. Price $6.00.

BASIC SKILLS IN MATHEMATICS, by H. Vernon Price and Lloyd Knowler, *The State University of Iowa*. Cloth. Pages viii+249. 13.5×21 cm. 1952. Ginn and Company, Statler Building, Boston 17, Mass. Price $3.25.

EVERYDAY PHYSICS, by Ole A. Nelson, *Wilson High School, St. Paul, Minnesota*, and John C. Winans, *Associate Professor of Physics, University of Wisconsin*. Cloth. Pages ix+614. 17.5×23 cm. 1952. Ginn and Company, Statler Building, Boston 17, Mass. Price $4.36.

UHF PRACTICES AND PRINCIPLES, by Allan Lytel, B.S., *Lecturer in Electronics, Temple University, Technical Institute, Trenton, N. J.* Cloth. Pages ix+390. 14×21 cm. 1952. John F. Rider Publisher, Inc., 480 Canal Street, New York 13, N. Y. Price $6.60.

TEXTBOOK OF QUANTITATIVE INORGANIC ANALYSIS, Third Edition, by I. M. Kolthoff, Ph.D., *Professor of Analytical Chemistry, University of Minnesota,* and E. B. Sandell, Ph.D., *Professor of Analytical Chemistry, University of Minnesota.* Cloth. Pages xv+759. 15×23.5 cm. 1952. The Macmillan Company, 60 Fifth Avenue, New York 11, N. Y. Price $6.50.

MATHEMATICAL MODELS, by H. Martyn Cundy, *Sixth Form Mathematical Master, Sherborne School,* and A. P. Rollett, *formerly Senior Mathematical Master, Sevenoaks School.* Cloth, 240 pages. 13×21.5 cm. Oxford University Press, 114 Fifth Avenue, New York 11, N. Y. Price $5.50.

EUROPE, Second Edition, by Samuel Van Valkenburg, *Clark University,* and Colbert C. Held, *University of Nebraska.* Cloth. Pages xiv+826. 14.5×23 cm. 1952. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. Price $7.50.

FUNDAMENTAL PROCEDURES OF FINANCIAL MATHEMATICS, by Merrill Rassweiler, Ph.D., *Associate Professor of Physical Science and Mathematics, The General College, University of Minnesota,* also by Irene Rassweiler. Cloth. Pages vii+260. 15×23.5 cm. 1952. The Macmillan Company, 60 Fifth Avenue, New York 11, N. Y. Price $3.25.

INTRODUCTORY GENERAL PHYSICS, by John Gibson Winans, *Associate Professor of Physics, University of Wisconsin.* Cloth. Pages x+765. 15.5×23 cm. 1952. Ginn and Company, Statler Building, Boston 17, Mass. Price $5.75.

INTRODUCTORY MYCOLOGY, by Constantine John Alexopoulos, *Professor of Botany and Plant Pathology, Michigan State College, East Lansing, Michigan.* Cloth. Pages xiii+482. 14.5×23 cm. 1952. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. Price $7.00.

THEORY OF NUMBERS, by B. M. Stewart, *Associate Professor of Mathematics, Michigan State College, East Lansing, Michigan.* Cloth. Pages xiii+261. 13.5×21 cm. 1952. The Macmillan Company, 60 Fifth Avenue, New York 11, N. Y. Price $5.50.

INORGANIC CHEMISTRY, AN ADVANCED TEXTBOOK, by Therald Moeller, *Associate Professor of Chemistry, University of Illinois, Urbana, Illinois.* Cloth. Pages ix+966. 14.5×23 cm. 1952. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. Price $10.00.

COLLEGE GEOMETRY, Second Edition, Revised and Enlarged, by Nathan Altshiller-Court, D.Sc., *Professor Emeritus of Mathematics, University of Oklahoma.* Cloth. Pages xix+313. 14×21 cm. 1952. Barnes and Noble, Inc., 105 Fifth Avenue, New York 3, N. Y. Price $4.00.

GENERAL MATHEMATICS AT WORK, by Claude H. Ewing, *Director of Instruction and Vocational Education, Kamehameha Schools, Honolulu, Hawaii, formerly Director, Chicago Schools;* and Walter W. Hart. *Author of Mathematics Texts.* Cloth. Pages v+266. 14.5×22.5 cm. 1952. D. C. Heath and Company, 285 Columbus Avenue. Boston 16, Mass. Price $2.80.

ROCKS, RIVERS AND THE CHANGING EARTH, A FIRST BOOK ABOUT GEOLOGY, by Herman Schneider and Nina Schneider. Cloth. 181 pages. 15×21.5 cm. 1952. William R. Scott. Inc., 8 W. 13th Street, New York 11, N. Y. Price $3.00.

SUN, MOON, AND PLANETS, by Roy K. Marshall, *Educational Advisor for Philadelphia's WFIL and WFIL-TV*. Cloth. Pages xii+129. 12×19 cm. 1952. Henry Holt and Company. 383 Madison Avenue, New York 17, N. Y. Price $2.50.

THANKS TO TREES, THE STORY OF THEIR USE AND CONSERVATION. by Irma E. Webber. Cloth. 60 pages. 16×19.5 cm. 1952. William R. Scott, Inc., 8 W. 13th Street New York 11, N. Y. Price $2.00.

DISCOVERING NUMBERS, by Leo J. Bruecker, Elda L. Merton, and Foster E. Grossnickle. Cloth. 346 pages. 14×21 cm. 1952. The John C. Winston Company, 1010 Arch Street, Philadelphia 7, Pa.

LEARNING NUMBERS, by Leo J. Bruecker; Elda L. Merton, and Foster E. Grossnickle. Cloth. 346 pages. 14×21 cm. 1952. The John C. Winston Company, 1010 Arch Street, Philadelphia 7, Pa.

EXPLORING NUMBERS, by Leo J. Bruecker, Elda L. Merton, and Foster E. Grossnicke. Cloth. 376 pages. 14×21 cm. 1952. The John C. Winston Company. 1010 Arch Street, Philadelphia 7, Pa.

UNDERSTANDING NUMBERS, by Leo J. Bruecker, Elda L. Merton, and Foster E. Grossnickle. Cloth. 378 pages. 14×21 cm. 1952. The John C. Winston Company, 1010 Arch Street, Philadelphia 7, Pa.

BOB WHITE, by R. W. Eschmeyer. Cloth. 50 pages. 12×17 cm. 1952. Fisherman Press, Oxford, Ohio. Price $1.50.

LABORATORY MANUAL FOR INTRODUCTORY CHEMISTRY, by Lillian Hoagland Meyer, *Western Michigan College of Education, Kalamazoo, Michigan*. Paper. 114 pages. 21×28 cm. 1952. The Macmillan Company, 60 Fifth Avenue, New York 11, N. Y. Price $1.75.

CORE CURRICULUM DEVELOPMENT PROBLEMS AND PRACTICES, by Grace S. Wright. Bulletin 1952, No. 5. Pages vi+104. 14.5×23.5 cm. Superintendent of Documents, U. S. Government Printing Office, Washington 25, D.C. Price 30 cents.

THE ROCKEFELLER FOUNDATION, A REVIEW FOR 1950 AND 1951, by Chester I. Barnard, *President of the Foundation*. Paper. 123 pages. The Rockefeller Foundation, 49 W. 49th Street, New York, N. Y.

NEW RESOURCES BRING NEW OPPORTUNITIES, Seventh Quarterly Report to the President by the Director of Defense Mobilization, October, 1952. Pages iv+44. 20×26 cm. Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price 30 cents.

BOOK REVIEWS

DIALOGUES CONCERNING TWO NEW SCIENCES, by Galileo Galilei. Translated by Henry Crew and Alfonso de Savio. Paper. Pages xxi+288. 13.7×20.3 cm. 1914. Dover Pub. Inc. New York. Price $1.50.

MATTER AND MOTION, by James Clerk Maxwell. Notes and Appendices by Sir Joseph Larmor. Originally published in 1877. Paper. Pages xi+178. 13.7×20.3 cm. Dover Pub. Inc. New York. Price $1.25

These two "classics" of physical science are prepared in this inexpensive form for use as source books for students of physics. Except for minor editing

and notes each book contains the subject matter as originally prepared by its author. (Galileo's as translated.)

Two New Sciences was first printed in Leyden, Holland, in 1638. G. Burneston Brown of University College, London, says that "In this brilliant, lucid and witty book, Galileo effectively destroyed the authority which the Middle Ages gave to Aristotle, and challenged (a good deal more effectively than he anticipated) the authority which the Middle Ages gave to the Church on matters pertaining to the physical universe. As a result, he was summoned before the Inquisition, and forced to abjure his belief that Copernicus was correct in asserting that it was the Sun which was stationary at the center of the universe, and not the Earth. In order to bring out the arguments for the two rival systems . . . Galileo adopted the dialogue form, introducing his readers to three gentlemen . . . with whom, he says, he had conversed in the 'Stupendious City of Venice.' " (From page 151 of *Science: Its Method and Its Philosophy*.)

The first of "The Two Sciences" is concerned with cohesion and properties of solids; the second, which is treated at greater length, is on motion with three sub-heads; uniform, accelerated and violent (projectiles). The dialogue is aided by 126 figures and numerous tables. Geometry rather than Algebra is the method of theoretical approach. A double columned four page index, a five page introduction and prefaces by translators, author and publishers helps to place book in its historical setting.

In *Matter and Motion*, Maxwell proposes to relate "forces acting between one body and another" to "the energy of a material system as determined by the configuration and motion of that system in which the ideas of configuration, motion and force are generalized to the utmost extent warranted by their physical definitions." It is expected that the reader will seek "to guide the current of (his) thought along the channels of dynamic reasoning. *Matter and Motion* . . . therefore, (is) an introduction to the study of Physical Science."

The editor, Sir Joseph Larmor, has provided an introductory note, a brief biography of the author and numerous footnotes as well as an appendix chapter on Relativity of Forces of Nature and one on Principle of Least Action. An over-brief index is supplemented by a 149 itemed table of contents.

Both of these books are descriptive in style though not avoiding the mathematical. Maxwell's "vector exposition . . . may seem somewhat abstract" to present day readers. However, any reader interested in the history of physics will find these two reprints of great interest.

B. Clifford Hendricks
Longview, Washington

College Mathematics, by Charles E. Clark, Associate Professor of Mathematics, Emory University. Cloth. Pages vi+331. 1950. Prentice-Hall Inc., 70 Fifth Avenue, New York.

This text offers a first course in mathematics for college students. It is prepared with three types of students in mind: those with weak background in high school mathematics, those for whom this will be a terminal course, and those who will continue the study of the subject. The book is adaptable to either a semester course or a full year course.

An interesting feature of the text is that it does not start with a long review of elementary algebra. The author believes that he gets better results by starting with material that is new to many students, then teaching the necessary algebraic manipulations as the need arises. The first topic is logarithms. Other topics follow in this order: trigonometry, differentiation, equations, applications of the derivative, integration, frequency distributions, correlation, permutations, combinations, probability, binomial distribution, sampling, curve fitting, annuities, and the trigonometric functions and identities.

The author includes the work in statistics and the calculus because he believes these topics have greater significance to the student who does not continue in mathematics than do some of the traditional topics in college algebra and

trigonometry. The topics from algebra, trigonometry, etc. are each developed independently of the rest of the book so that the instructor can readily rearrange the order of topics as he desires. The material covered lays an adequate foundation for studying analytics as a next course .

The author states that a distinctive feature of the book is the exposition of the topics. For example, differentials and derivatives are proved to be good approximations to increments and rates, in this treatment which is limited to positive and negative powers of an independent variable. The fundamental notion is that of approximation and not that of limit. Thus the treatment is not a shortened form of a part of sophomore calculus.

The book contains answers to the odd-numbered exercises, five place tables of logarithms, and five place tables of the natural trigonometric functions. Drawings and general appearance are very good.

A study of the author's presentation of various topics indicates that he has done very well the things that he proposes in the preface. At least some of his explanations are definitely more simple for the student to understand than those usually found in college texts. It seems to the reviewer that the content would be very difficult for the freshman student who has a poor background in high school mathematics. However, classroom use can best answer that question. The text deserves the careful study of those seeking such a book.

GEORGE E. HAWKINS
Lyons Township High School and LaGrange, Ill. Junior College

PLANE TRIGONOMETRY, Third Edition, by Lyman M. Kells, *Professor of Mathematics*, Willis F. Kern, *Associate Professor of Mathematics (Retired)*, and James R. Bland, *Professor of Mathematics, United States Naval Academy*. Pages xiv+188. 1951. McGraw-Hill Book Company, Inc., New York. Price $3.50.

This text is a revised edition of the 1940 book by the same men, a revision so complete that the authors state that it affects every section of the book. Items that did not seem to serve a useful purpose have been eliminated. Other changes involve changing the logical and the pedagogical order, simplifying major developments, and the addition of new proofs, new theory, and new problems. The authors' plan is to develop the fundamentals of a topic in detail and then to bring in natural extensions directly suggested by the thoroughly understood basic material. Their plan also uses very short problems at the beginning of lists, problems requiring careful thinking and a minimum of pencil work. The use of the slide rule, particularly as a check on long computations, is explained and recommended in connection with several different topics.

The content of the text is the same as that found in most other trigonometries. The approach to the subject is through the definitions of the functions for the acute angle only. The functions for the general angle are defined in Chapter IV. The book contains both four place and five place tables and the answers to odd and even numbered exercises.

The general appearance of the printed page is very good. Drawings and illustrations are excellent. The book deserves careful examination by anyone considering a new textbook in trigonometry.

G. E. HAWKINS

MATHEMATICS FOR SUCCESS, by Mary A. Potter, *Supervisor of Mathematics*, Anne L. Neitzel, Dorothy A. Root, Frances C. Enright, *Washington Park High School, Racine, Wisconsin*. Pages viii+440. 1952. Ginn and Company, New York. Price $2.68.

For several years some schools have been experimenting with a second year of practical or general mathematics for those high school pupils who are not enrolled in the traditional algebra and geometry courses. However no textbooks have been

available which were planned specifically for a second course. *Mathematics For Success* is offered as a text for a second course in practical mathematics.

The authors point out that at the end of grade nine many pupils have not acquired functional competence in mathematics, that many are in need of further practice in arithmetical computation, that they are old enough to begin to be interested in certain applications of arithmetic to social situations, and that some have matured sufficiently to understand an extension of useful algebra and intuitive geometry that is significant in the life of the average adult.

The text includes arithmetic, some algebra, informal geometry, and applications. The chapter headings are as follows: signed numbers, decimals, the micrometer, the formula and the equation, percentage, budgets and interest, statistics, planning for the future, some geometry, installment buying, ratio and proportion, scale drawing, similar figures, taxation, the right triangle, trigonometry. The authors point out that the content included in the text is the result of careful experimentation over a period of several years.

Most teachers would agree that the content is significant, that it is material with which high school graduates should be familiar. Examination of the topics covered and the extent to which each is pursued shows that the content and treatment parallels quite closely several texts in general mathematics or practical mathematics that have been available for several years and that have been suggested particularly for use in grade nine. Thus a teacher who has been teaching such a course in grade nine would probably not be interested in this text for a second course. On the other hand the teacher who has been offering a course in grade nine that is largely arithmetic and its applications or one in which the content does not overlap that covered in this text to any great extent may find here a text that appeals to him.

The general topography of the book is very good. Illustrations and drawings are excellent. In the explanations the authors have attempted to write to and for the pupils. There is an abundance of exercises for practice. Both the authors and the publishers are to be congratulated for their pioneering in offering a text for a second course in this area.

GEORGE E. HAWKINS

NOMOGRAPHY AND EMPIRICAL EQUATIONS, by Lee H. Johnson, *Tulane University*. Cloth. Pages ix+150. 14.5×23 cm. 1952. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 6, N. Y. Price $3.75.

It would seem that the author has in mind a text which will provide a working knowledge of nomographs and of empirical equations, rather than a presentation of all the underlying theory. The individual working in an applied field is likely to find this book more useful than other available references. The explanations are unusually careful and complete; there are many illustrative examples and diagrams, with explicit instructions for procedure. The basic theory behind the nomograph is based upon plane geometry, with emphasis on similar triangles, with no mention of determinants. The reader needs a good working knowledge of logarithms.

Unfortunately, at many spots one finds ambiguous, conflicting, or erroneous statements; it is unfortunate that more careful editing did not catch many of these. In the preface it is stated that empirical equations are the mathematical expressions of data plotted in the form of curves—one wonders why the data need be plotted at all; the empirical equation could still be obtained. Three methods of curve fitting are presented (selected points, averages, least squares; the method of moments is not given). On page 96 the flat statement is made that the method of selected points is the least accurate of the three methods but on page 102 we discover that when the points are scattered, the method of averages may give the least accurate results. Ignoring the contradiction, it seems conceivable that certain selections of points might give a more accurate result than the method of averages. Likewise it is usually, but *not necessarily* true that a more accurate solution is obtained if the points are not taken too close together (page

97). In discussing the method of averages the flat statement is made that the best procedure is to put the first half on the points in one group and the second half in the other. The statement is ambiguous—does first half mean first in order of size of one variable, or first in order of observation of data? In either case, although the rule may usually be the best procedure, what assurance is there that it is always best?

The statement that the method of least squares has been proved mathematically to give the best line to fit the data (page 100) shows careless reading of the reference cited. "Best fit" depends upon what we define to be a good fitting line—for example would the author's method of least squares give the best fitting line if we define this as one for which the sum of the perpendicular distances of the points from the line to be a minimum?

After the author has carefully avoided the use of determinants in developing the theory of nomographs it is a little surprising to find casual mention of solving four simultaneous equations by determinants (page 144). It is also unexpected to encounter a reference to partial differentiation as a method for minimizing an expression, since this could have been shown without reference to calculus.

There are 125 problems which could furnish good exercises if the book is to serve as a class text. The absence of answers, which would propose some difficulty in the case of nomographs, but essentially no trouble for problems dealing with empirical equations, lessens the value of the book for the reader studying independently. In fairness, it must be stated that the criticisms of the reviewer may seem relatively trivial to the individual seeking a working knowledge of the topics covered—indeed he may find this book one of the best on the market.

CECIL B. REED
University of Wichita

COLLEGE ALGEBRA by Ross R. Middlemiss, *Professor of Mathematics, Washington University*. Cloth. Pages xix+344. McGraw-Hill Book Co., 330 42nd Street, New York 36, N.Y. Price $3.50.

The topics covered in this text are essentially traditional. In the opinion of the reviewer there are however certain features which make the book worthy of careful examination when selecting a new text. The explanations are exceptionally clear and completed problems seem well selected to illustrate the important points. Among the somewhat unusual features worthy of mention: a suggested lesson schedule of forty-eight assignments with problem lists (as the author points out, few schools could cover forty-eight assignments in a semester but variation in emphasis and omitted topics will no doubt reduce the list); excellent discussion of division by zero; and explanation of why $\sqrt{16}=4$ instead of ± 4: emphasis upon the difference between theorem and converse and between a necessary and a sufficient condition, in particular why mechanical rules may give a value which is the only possible solution of an equation but this value is not necessarily a solution. There is a rigorous statement that the base cannot be zero in defining a negative or zero exponent; likewise the definition of a mantissa is unambiguous, unlike some texts.

The author reverses the customary first and second parts in the proof by mathematical induction with reasons for this reversal. His problem list in this section contains some excellent exercises illustrating the need for both parts of the proof and including some formulas (for some reason these are called theorems), which the student must determine to be either true or false. The author shows that synthetic division may be used to find a lower bound for the negative roots of an equation without transforming to $f(-x)$ as is customary. In introducing the polar form of complex numbers the author first reviews some needed trigonometry.

There are a few places which will not please all readers. The statement that a single symbol (i) is all that is needed to extend the real number system to include the complex numbers might give the impression that the square root of a/b is equal to the square root of a divided by the square root of b irrespective of wheth-

er a and b are positive or negative numbers. Is it completely correct to say that no formulas exist for the solution of an equation of a degree higher than four? Some will question the statement that variation is of little importance from the viewpoint of the mathematician: modern insurance calculations use other tables in addition to the America Experience Table of Mortality. Some prefer to introduce at least second order determinants earlier than page 239. These points are relatively minor when contrasted with the many excellent features of the text.

CECIL B. READ

MATHEMATICS FOR TECHNICAL STUDENTS, BOOK III, by J. D. N. Gasson, M.A., *Senior Lecturer in Mathematics, Chesterfield Technical College.* Cloth. Pages xi+451. 13.5×21.5 cm. 1951. Cambridge University Press, American Branch, 51 Madison Avenue, New York 10, N.Y. Price $3.50.

This book, written for British schools, covers the material of algebra, trigonometry, analytic geometry, and calculus. Aside from a few differences in terminology (i.e., revision for our review; gradient for our slope) the American student would have no trouble in reading the text. The subject matter covered does not coincide with that taught in many of our colleges—for example the material on algebra does not cover determinants, permutations and combinations, theory of equations, inequalities, variation; on the other hand the material in trigonometry in several places goes beyond that covered in an introductory text.

The treatment is somewhat traditional, there are examples, with answers, at the end of the chapters, and at the end of the book, twenty-eight pages of "revision examples."

It is doubtful if the book would be a satisfactory text in most American colleges; it does furnish many suggestions for supplementary material, and would be a good source of problem material. As is often the case with text written for British use, it is the variation in emphasis in the two countries, rather than the merit of a book, which makes it not the best choice for a text in a beginning course.

CECIL B. READ

CALCULUS, by John F. Randolph, Ph.D., *Professor and Chairman of the Department of Mathematics, University of Rochester.* Cloth. Pages x+483. 15×23.5 cm. 1952. The Macmillan Company, 60 Fifth Avenue, New York 11, N .Y. Price $5.00.

The author states that preparation and interest in mathematics show such variation that a calculus text must provide routine knowledge of the subject and its applications, yet still challenge the good student. There is little question that this book will meet the latter objective, whether by judicious selection of material the instructor may use the text with a class of average or below average students may depend upon the ability of the instructor. Some teachers will feel that the presentation is too difficult to be grasped by such students.

The text has some unusual features, many of which offer distinct possibilities for the student reaching a better understanding of the meaning of calculus. To mention a few, the discussion starts with the concept of tangents to a curve, using the analytic geometry approach, rather than a study of limits. A function is defined in terms of ordered pairs of elements; derivatives of the sine and cosine are introduced very early in the book, likewise the concept of antiderivatives (not called integrals when introduced) the definite integral is introduced before the indefinite.

There is a 34 page chapter on solid analytic geometry—this could be a part of an analytic geometry text, there being no use of calculus. The discussion of relative maximum and minimum values emphasizes the need of considering end values of the domain of definition, often not mentioned in an elementary text. In discussing sequences there is a problem to illustrate the fact that examining a few terms does not give the law of formation—six different sequences are given, all having the first terms 1, $\frac{1}{2}$, $\frac{1}{3}$.

In several places the content is beyond that found in many elementary texts: directional derivatives, line integrals, Green's theorem, derivatives of vectors, Gauss's three point rule for approximating a definite integral; additional material in the appendix such as proofs of limit theorems and calculus of power series. On the other hand, some teachers would prefer a more complete treatment of elementary differential equations. It is not pointed out that alternative definitions for the principal values of the inverse trigonometric functions exist; methods of expressing a fraction as partial fractions are given with no explanation of the "why"; in presenting Newton's method it is pointed out that the second approximation obtained may not be as good as the first but no mention is made of means available to avoid this difficulty.

There is an ample supply of problems, with answers to selected exercises. Very definitely this book merits consideration when adoptions are being discussed.

CECIL B. READ

MODERN PHYSICAL SCIENCE, by William O. Brooks, *Science Teacher, Technical High School, Springfield, Massachusetts* and George R. Tracy, *Head of Science Department, Polytechnic High School, Long Beach, California. 569 pages.* 15×23.5 cm. Henry Holt and Company Inc. 1952. Price $3.80.

This is a textbook written to meet the needs of the large group of students wanting an interesting, yet, nonmathematical physical science course. The practical aspects of the physical sciences are stressed in this book.

"The book is organized into 16 units, each of which covers a major subdivision in physical science." The first three units emphasize the fundamental quantities of the physical sciences. The subsequent units may be used in any order to suit the interests and needs of the class. Each teacher has his own ideas of sequence, so this flexibility should be of value.

The many illustrations should give the students many ideas for carrying on projects and experiments on their own. The use of tables listing important ideas will be of value to the students for review. The 133 page glossary will be of help to students in learning the meanings of the many words used in science.

For teachers interested in starting a physical science course, this book should be examined.

E. WAYNE GROSS
University School
Bloomington, Indiana

EXPLORING PHYSICS, by Hyman Ruchlis, *Chairman of Science Department, Bushwick High School*, New York City, in consultation with Harvey B. Lemon, *Department of Physics, University of Chicago*, under the editorship of Paul F. Brandwein, *Chairman of Science Department, Forest Hills High School, New York City*. 637 pages. 16×23.5 cm. Harcourt, Brace and Company. 1952. Price $3.96.

The introduction to the book is striking. Each unit is introduced by a well chosen picture and short paragraph about each of the seven units. The usual appendix is missing from the book. This information is inserted in the text itself where it is needed. There are activities, questions and problems at the end of each of the 45 chapters. The problems are varied and practical in nature. Each chapter and unit includes a few more difficult problems for the better students. The illustrations and many line drawings aid the student in understanding the textual material.

Since students of all levels of ability are often in the same physics class, the way in which the mathematics is treated in this book will make it of value. The more difficult mathematical concepts are placed in separate subsections so they may be used optionally.

E. WAYNE GROSS

MOURNING DOVES IN WISCONSIN

Even rural mail carriers help with wildlife censuses in Wisconsin.

This was reported today to the 13th Midwest Wildlife conference by Fred H. Wagner, teaching assistant in wildlife management at the University of Wisconsin.

The census was part of a study of the mourning dove, a good subject for research on population mechanisms. Because the dove is not a game bird in Wisconsin, however, funds for its study are limited.

But mail carriers do exactly what a bird census biologist does—they travel over the same area day after day.

Wagner asked the carriers if they would watch the roadside for the mournful songster and count the number seen on three designated days. The state was divided into areas, and the carriers made their counts as spring climbed north.

From an estimated 1,000 carriers in the state, Wagner got 871 dove counts—more than enough for a significant scientific report.

"It was hoped that the same point in the nesting season was being hit throughout the state," Wagner said, "preventing a survey of Southern Wisconsin while all birds were nesting and of Northern Wisconsin when all migrants had not yet arrived."

Wagner converted the observations by the mail carriers into doves per hundred miles, and he found that doves occur in fair numbers in the part of the state west of a line drawn from Superior to Racine.

"With this type of knowledge," he told the conference, "it should be possible to show climate, soil, vegetation, and land-use relationships essential to a management program to increase dove populations." The information, he pointed out, will also be of use to biologists who deal with other bird species, and to biologists in states where the dove falls within the game bird category.

SPRAYING CORN FROM GROUND BETTER THAN AIRPLANE DUSTING

Ground rig sprays of DDT may replace airplane dusting for corn earworm, a serious sweet corn pest.

O. G. Bacon, of the University of California College of Agriculture, in the third year of field trials against the pest, found that three applications of DDT with a ground rig gave very good control at less cost than the usual five to seven airplane dustings per season.

The ground rig used was equipped with a boom fitted with spray nozzles to spray two rows of corn. As it passes through the corn field it shoots the spray on both sides of the plant aiming at the area where the ears are growing. Commercial machines are capable of spraying as many as six rows of corn.

Several new insecticides were used in the tests but DDT gave the best results.

In general, airplane applications have not resulted in as good control as sprays applied by ground equipment. The airplane dustings do not always cover the corn silk, where the chemical is most needed. The problem of dust drift to adjoining fields makes airplane applications unsatisfactory at times.

Individual hand brushing with dust and individual hand spraying with a paint-type spray gun were also tested using DDT and other chemicals. Both methods of application gave good results but required a large number of workers to cover the fields quickly.

Hex tents, now in Korea ready for use to keep soldiers warm in sub-zero weather, are six-sided in shape and accommodate five men. Important feature is a white lining that provides insulation and also reflects light better than the usual tent and prevents frost from falling on the occupants.

THE MANUFACTURERS VIEW EDUCATION

Education is an ancient enterprise which has been a power in developing the resources and in shaping the future both of society and the individual. The importance of education as the foundation of democratic liberties and as a bulwark of freedom is generally recognized. Although the American people have accepted the need for and are committed to provide an organized system of education for the benefit of all the people, that obligation has not yet been satisfactorily fulfilled.

At a time when our schools should be expanding to meet the needs of increasing numbers of students, current support in many instances is proving inadequate. The economic pressure upon teaching personnel to seek better compensated employment in fields outside the teaching profession is a challenge to the American people to recognize the teacher as an indispensable member of society and to provide attractive compensation for teachers together with favorable school conditions.

All phases of American society are beneficiaries of the educational system, but no single group, class or partisan interest has a preferred claim. The contribution of education to the whole American culture creates in each segment of society a responsibility for its support and development.

Manufacturers have a sincere desire to see established and maintained an educational system which meets the varying and changing needs of the individual and of society and which should be consistent with the American way of life.

Paper dinner plates that do not get soggy and limp are made by impregnating sulfite paper with a melamine resin blend and molding the paper into the desired shape by compression. Disposable after use, the plates are greaseproof and heat resistant. They are made in dinner, compartmented and pie sizes.

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YELLOWSTONE GEYSER ERUPTS AFTER 60 YEARS

Most important event of 1951 concerning geysers is the eruption, for the first time in nearly 60 years, of Splendid Geyser at Yellowstone National Park.

Since 1892, when it became dormant, there has been no proved natural eruption of this geyser. Since 1892 the nearby geyser, Daisy, began erupting frequently and with considerable regularity at intervals of approximately one hour and 40 minutes. Since then, Daisy has played about 4,500 times each year, during all of which time until this year the Splendid lay quiet.

Old Faithful continued to put on its regular performance, but fewer people were observed watching the show. The fence that has been erected to protect the geyser from too-curious visitors during the winter season is leaving scars in the base of Old Faithful's cone, and park naturalists are searching for some other way of protecting the geyser.

During 1951, 74 of the named hot springs were observed in eruption while 45 unnamed geysers were seen playing. A few of the major geysers were unusually active during the year. Besides the usual and dependable performers, such as Old Faithful, other geysers that put on a regularly good show were Splendid, Giant, Mastiff and Catfish.

The rejuvenation of the Splendid, after its long quiet period when naturalists had thought it dead and Daisy the successor, is aiding the understanding of geysers' activities. It has helped to show, in a spectacular manner, that there is an exchange of function between geysers which are connected underground. George D. Marler, park naturalist, states that the length of time between this exchange is not only indefinite, but long.

OCCUPATIONS—A BASIC COURSE FOR COUNSELORS*

The science of occupations is a relatively new field of study. Few colleges offer any guidance course concerned with occupations, yet the bewildering array of more than 22,000 ways of earning a living remains a constant challenge to men and women of all ages.

This bulletin is designed to aid colleges and universities in their effort to prepare counselors adequately in the science of occupations. The suggestions given will be of special value to counselor trainers, State directors of vocational education, State supervisors of occupational information and guidance, directors and staffs of schools of all types, teachers of occupations classes in high schools, and school counselors.

A basic course in occupations is vital to all those who counsel young people about their future jobs.

* Walter J. Greenleaf. Office of Education, Vocational Division Bulletin No. 247. 1951. 193 pages. For sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. 45 cents.

TEACH IN CHICAGO

Examinations for teachers of Chemistry & Physics in the Chicago Public High Schools will be held April 28, 1952.

Closing date for filing formal application forms and required credentials is April 14, 1952. For information apply to

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INSECT ELLIS ISLAND SET UP ON WEST COAST

A new West Coast "Ellis Island for Insects" has been set up at Albany, Calif., to handle the safe importation of beneficial insects.

The imported "bugs that fight bugs" are liberated to fight against the agricultural pests which have reached California from foreign countries, having left their natural enemies behind.

For nearly 30 years the University of California's Division of Biological Control has maintained quarantine quarters at Riverside in the southern part of the state.

The establishment of the Albany unit provides additional facilities to test insects that may control agricultural pests in central and northern California. The location is close to steamship and air terminals at San Francisco.

Opened recently, the quarantine laboratory has already received collections from all over the world; parasites of the olive scale from India and Pakistan, parasites of the elm scale and fig scale from France, a small ladybird beetle from Australia which preys on mites.

The quarantine material is handled by the University of California's College of Agriculture through agreement with the United States and the California State Departments of Agriculture. It is the only state institution in the United States granted quarantine privileges because of its trained personnel and especially-designed facilities for quarantine work.

EXPERIENCE IN CHEMICAL INDUSTRY

Monsanto Chemical Company announced reactivation of a program which permits university and college faculty members in chemical engineering to gain a full year's on-the-job experience in the chemical industry.

In announcing the reactivation of the plan, which originally began in June, 1948, Dr. Carroll A. Hochwalt, vice president in charge of technical activities for the company, said that the earlier program had been very successful in giving professors practical experience in industrial operations which could be utilized in teaching successive classes of students.

Faculty men chosen for participation in the program receive a year's leave of absence from the college or university to take technical positions with Monsanto. At the end of this year they return to teaching.

The program is the reverse of another Monsanto plan for leaves of absence for academic purposes, Dr. Hochwalt said. Under the latter plan some of the company's industrial scientists have been selected to return to universities of their choice for an academic year of study at full pay.

WARNING DEVICE FOR BUSES FORESTALLS BRAKE FAILURES

There will be less danger of accidents involving city buses with a new electrical device which gives warning of the loss of oil in their hydraulic systems and consequent brake failure and loss of steering power.

This alarm system has been thoroughly tested on buses in Miami, Fla., and in New York City. It is a product of the Bendix Aviation Corporation and was described here today to the American Institute of Electrical Engineers by F. O. Wisman and W. E. Windsor of the Bendix company.

In the system, a sensory cartridge containing a thermistor is placed in the oil reservoir and connected in series with a battery and alarm lamp or buzzer. The thermistor is a device in which the electrical conductivity is radically influenced by temperature. This thermistor consists of ceramic materials and various metallic oxides the latter group being generally known as semi-conductors.

HELEN PUTNAM FELLOWSHIP FOR 1952–1953

Radcliffe College offers for the eighth time for the academic year 1952–1953 the Helen Putnam Fellowship for advanced research, a postdoctoral resident fellowship for women in the field of genetics or of mental health, broadly defined to include such fields as clinical psychology and child development. The award carries a grant of $3,000 a year with the possibility of renewal.

Applications should be returned to the Secretary of the Graduate School, Radcliffe College, not later than April 1, 1952. Preference will be given to those whose research is already in progress.

Dean Bernice Brown Cronkhite of the Radcliffe Graduate School is chairman of the committee on awards, members of which include the following representatives of the Harvard University faculty: Gordon W. Allport, professor of psychology; Stanley Cobb, professor of neuropathology; Alden B. Dawson, professor of zoology; Leigh Hoadley, professor of zoology; Karl Sax, professor of botany; Robert R. Sears, professor of education and child psychology; and Edwin B. Wilson, professor of vital statistics, emeritus.

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